

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING,

Letter from the Chief of Engineers, United States Army, and accompanying report of Col. J. H. Simpson, Corps of Engineers, of survey to estimate the damage done to the town of Venice, Ill., by reason of the government improvements on the Mississippi River.

JANUARY 6, 1880.—Referred to Committee on Commerce and ordered to be printed, with accompanying documents.

WAR DEPARTMENT, WASHINGTON CITY,
December 19, 1879.

The Secretary of War has the honor to transmit to the United States Senate a letter from the Chief of Engineers, of the 16th instant, and accompanying copy of report from Col. J. H. Simpson, Corps of Engineers, of a survey and examination made in compliance with the provisions of the river and harbor act of June 18, 1878, to estimate damages to riparian owners of lands in front of the town of Venice, Ill., by reason of government improvements on the Mississippi River.

ALEX. RAMSEY,
Secretary of War.

THE PRESIDENT
of the United States Senate.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., December 16, 1879.

SIR: I have the honor to submit herewith a copy of a report to this office from Col. J. H. Simpson, Corps of Engineers, of the results of a survey and examination made in compliance with provisions of the river and harbor act of June 18, 1878, requiring "a survey and estimate of the damages, if any, done or to be done to riparian owners of lands, and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made or to be made at or near said town of Venice."

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brigadier and Brevet Major-General, U. S. A.

HON. ALEXANDER RAMSEY,
Secretary of War.

SURVEY AND ESTIMATE OF THE DAMAGES TO RIPARIAN OWNERS IN FRONT OF THE TOWN OF VENICE, ILL., BY REASON OF GOVERNMENT IMPROVEMENTS MADE OR TO BE MADE AT OR NEAR SAID TOWN.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., April 10, 1878.

GENERAL: According to the instructions contained in your letter dated May 1, 1877, requiring a survey and estimate to be made "of the damages, if any, done or to be done to riparian owners of lands, and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made, or to be made, at or near said town of Venice," a survey was made by my assistant, Mr. William Popp, in September and October, 1877.

The accompanying map of this survey, on a scale of 1 inch to 200 feet, embraces the towns of Venice and Brooklyn, the Mississippi River from Bischoff's dike to head of Bloody Island, and the river front of the city of Saint Louis from Ferry to Florida streets. The towns of Brooklyn and Venice are laid down on the authority of the public records of Saint Clair and Madison Counties. The subdivision of the lands of the Madison County Ferry Company is copied from a map or plan loaned for the purpose by the ferry company. The location of the old works, shown in blue and green, is not absolute, being transferred from the old maps, and depends on the accuracy of the surveys, and plotting of those maps. The full blue lines are taken from the map made by Lieut. R. E. Lee, in 1839, and the broken blue lines are from a map compiled by Henry Kayser, city engineer of Saint Louis, in 1849. The works shown in green are taken from a map made from a survey in 1861, and represent the location and then condition of the early works. Red shore lines and figures are taken from the survey made in 1870 by Capt. Charles J. Allen, Corps of Engineers, and the black lines and figures represent the survey of 1877. Actual soundings are given in both cases, the stage being practically the same, $+7.3'$, at time of survey in 1870, and $+7^{\circ} 2'$ in 1879.

The examination of the question of damages necessarily involves a search of the records to ascertain what has been done and the purpose of the works, also any acts of the parties interested which would bear upon the question presented. This examination was made by my assistant, Robert E. McMath, and the result is embodied in a report upon the matter dated March 20, 1878, a copy of which is forwarded herewith. Mr. McMath arrives at the following facts bearing directly upon the question of damages:

1. Damages done previous to 1872 were compensated for by a payment made in 1841.

2. Said payment covered also damage to be done by completion of the plans then contemplated.

3. The party to whom payment was made is the same as the corporation now owning the entire Venice front.

4. The legislature of Illinois in 1849 recognized that the ferry company had relinquished their rights upon this front, for it recovered to the ferry company the right to use a certain dike to be built upon the ground owned by the ferry.

5. In recovering this right the legislature imposed certain conditions upon the ferry which have not been fulfilled.

6. The works built by the United States in 1873 do not materially

differ from those provided by the legislature in the interest of the riparian owners.

7. Another work stands in a position to impair the interests at Venice more directly than the one extended by the United States.

8. The only riparian interest besides that of the ferry company is subject to the acts and obligations of the ferry company from whom that interest derives title.

Upon the facts recited above the conclusion is reached, in which I concur, that no damage has been done by works actually constructed by the United States to the riparian owners of lands or the improvements thereon at or near the town of Venice.

Concerning the second branch of the inquiry, what damages will be done by future works, a definite answer cannot be given. If the recommendations of the Board of Engineers convened in February, 1872, be strictly adhered to the damages will be large, and will depend upon the then value and development of the local interests. There being no immediate probability of these works being carried out, it would be useless to estimate these interests now, if the means of making such an estimate were within reach. As the question depends upon information obtainable only from the books, officers, and employes of the ferry company, the only mode of arriving at a valuation is through the courts.

To avoid the question of damages in future, I concur in the opinion that it would be well to modify the plan of the board of 1872, and return to the lines agreed to and compromised upon in 1841 and 1849. To do this, however, would affect the interests of the city of Saint Louis in an important degree. Until the publication of this report and the accompanying papers affords an opportunity for the authorities of Saint Louis, and indeed all interested parties, to be heard, and possibly to suggest other solutions, I cannot indorse the recommendation of my assistant as to the immediate construction of the high dikes at the shore end of Bischoff's dike, and at the foot of Ferry street, Venice, for the construction of such works must depend upon their being accepted by the riparian owners in lieu of all possible claims for damage.

These conclusions are based upon an array of facts obtained with much labor from records and documents. In order to present the evidence upon which they are founded a memoir has been prepared, and is forwarded herewith, giving in narrative form a history of Saint Louis Harbor and the works for its improvement, to which a series of important reports is added as appendices A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, and Q, in evidence of facts and opinions.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brigadier-General A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. ROBERT E. M'MATH, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *March 20, 1878.*

SIR: Under the instructions of the Chief of Engineers, United States Army, dated May 1, 1877, requiring a survey and estimate to be made of the damages, if any, done or to be done to riparian owners of lands and improvements thereon, at or in front of the town of Venice, Ills., near Saint Louis, Mo., by reason of government improvements made or to be made at or near said town of Venice, a survey was made in September and October, 1877, by Mr. William Popp, assistant engineer.

Mr. Popp has prepared a map of his survey on a scale of 1 inch to 200 feet, embracing

the towns of Venice and Brooklyn, the Mississippi River from Bischoff's dike to the head of Bloody Island, and the river front of the city of Saint Louis from Ferry to Florida street. The lines of streets are laid down on the authority of the public records of Saint Clair and Madison Counties. The subdivision of the lands of the Madison County Ferry Company is copied from a map or plan loaned for the purpose by the ferry company. The location of the old works, shown in blue and green, is not absolute, being transferred from old maps, and the correctness of the locations indicated depends upon the accuracy with which the old surveys were made and plotted. The blue lines, showing the works done and designed in 1838-1841, are taken from the map made by Lee in 1839 and that made by Kayser in 1849. The dikes represented in green are taken from the map of the survey of 1861. The original map being on a scale of 1 inch to 250 feet, the errors of transfer are small. The red shore lines are taken from the survey of 1870 made under this office; also the soundings shown in red are of the same date. The black lines and figures represent the survey of 1877. The soundings of 1870 and 1877 were taken at practically the same stage of water, those of 1870 being made when the gauge read 7 feet above low water of 1863, and those of 1877 when the reading was 7.2. The actual depths are shown, for reduction of soundings to a standard plane is not admissible in silt-bearing rivers.

Comparing the red and black figures it will readily be seen that the depth generally over the area of river included in the survey has materially diminished since 1870. It is to be regretted that the amount of funds available did not permit the survey of 1877 to cover the whole width of the river; but the few lines that were run across indicate fully what would have been the general result of such a complete hydrographic survey. The outlying bar on the Saint Louis side prevented these lines being run to the shore.

By the survey of 1870 we have the data for an approximate cross-section about 200 feet below Bischoff's dike on the line *a' B'*, and by that of 1877 we have a cross-section at the dike on the line *A B*. These sections are shown superposed near the lower left-hand corner of the map. The section of 1870 is assumed to be limited by the then west end of the dike.

The area at a 7-foot stage in 1870 was 29,940 square feet; if we reduce the section to low water by subtracting $7 \times 1,426, 9.982$ square feet, we have a low-water area of 19,958 square feet.

Taking likewise the section of 1877, the area at 7.2-foot stage was 18,909 square feet; deduct to reduce to low water $1,560 \times 7.2$, 11,232 square feet, and we have a low-water area of 7,677 square feet.

The area, then, at a 7-foot stage in 1877 was but 63 per cent. of the area at a like stage in 1870, the reduction corresponding to an average deposit of 7 feet nearly entirely across the river; and from inspection of the map we may say that this average deposit covers the whole area shown on the map. By a like comparison of low-water areas that of 1877 was but 38 per cent. of the area of 1870. Assuming that equal gauge readings imply equal volumes of water passing, as is very commonly done in discussions of river phenomena, and the velocities must have been inversely as the area; that is the velocity in 1877 must have been to that of 1870 as 1.36 to 1.00, which is possible, but scarcely probable; but if we compare the low-water areas the velocity in 1877 would be to that in 1870 as 2.6 to 1.0, which is certainly impossible. These considerations suggest that reductions and arguments made from observations taken at one stage and applied to a considerably different stage are liable to mislead. In another place I have, in a discussion of a related topic, assumed an approximate low-water area at this locality of 15,000 square feet, which is as small an area as has actually been observed in the Mississippi below the Missouri. To approximate this area both the sections 1870 and 1877 must be enlarged as the river falls from a 7-foot stage to low water, and that of 1877 much more in proportion than that of 1870.

Many and serious errors have been made by scientists and engineers in their discussions of facts, theories, and plans connected with the Mississippi through applying principles and modes of reasoning which have been well established by the study of other streams, forgetting that the silt-bearing character of the Mississippi introduces new conditions which may well be expected to render the methods of applying old principles inappropriate, if they do not cast doubt upon the applicability of the principles themselves.

Cram, in his reports of 1843 and 1844, gave a clear and explicit statement that comparison of soundings taken in the Mississippi at various times and stages could not be made with propriety; and experience since has been a series of warnings against hasty opinions and generalizations. Taking the facts shown by these red and black soundings, it would be possible to say the bed of the river was being filled up, and we could find precedent for making out from observed facts a rate of progress from which a date could be fixed in the near future for the complete obliteration of the river-bed. To do so would be folly, and it would be scarcely less foolish, though the folly would not be so apparent, to attribute the shoaling of the water at the Venice Landing to the same cause as the shoaling of the river in general; and then to argue the uselessness

of the dikes, or even to say they have injured the navigation, for the avowed intention of the dikes was to deepen the water along the city front and to induce deposit on the Venice side. The dikes have narrowed the river; nevertheless the river is less deep than before. Looking for a rational solution of this seeming refutation of established principles, we will compare the gauge records for the two years, taking the highest and lowest stage for each calendar month from April to January. The graphical record for the same periods is shown on the map—red lines and figures refer to 1870 and black to 1877.

1870.	Highest.	1870.	Lowest.	1877.	Highest.	1877.	Lowest.
April 16.....	26.21	April 1.....	20.17	April 24.....	23.55	April 1.....	14.00
May 4.....	22.93	May 25.....	15.29	May 20.....	25.55	May 31.....	19.75
June 1.....	16.95	June 29.....	11.39	June 14.....	26.60	June 1.....	20.25
July 1.....	13.78	July 31.....	9.06	July 4.....	26.55	July 31.....	16.10
Aug. 15.....	10.16	Aug. 31.....	6.32	Aug. 1.....	15.75	Aug. 31.....	9.65
Sept. 21.....	11.66	Sept. 2.....	6.17	Sept. 4.....	11.10	Sept. 30.....	7.10
Oct. 7.....	12.46	Oct. 31.....	9.16	Oct. 29.....	12.85	Oct. 4.....	6.85
Nov. 5.....	17.83	Nov. 30.....	8.35	Nov. 28.....	13.70	Nov. 16.....	9.75
Dec. 1.....	8.25	Dec. 24.....	5.26	Dec. 31.....	16.75	Dec. 7.....	9.40

The soundings of 1870 were made December 9, seven months and twenty-three days after the highest water of the year. Those of 1877 were made October 16, three months and twelve days after the turn of the July rise. The record of 1870 shows no summer rise. The April or spring rise probably came in great part from the melting snows and spring rains in the Upper Mississippi basin and that of the Lower Missouri. The record of 1877, on the other hand, shows a long high-water season, arriving at its maximum in June, indicating that the waters came in a great part from the Missouri. The season of 1877, then, was one favorable to channel filling, and that of 1870 was quite the contrary. The waters of the Missouri are highly charged with sediment, and move with greater velocity in high stages than do the waters of the united rivers; consequently the bed of the Mississippi below the junction is a place of temporary deposit for a part of the Missouri sediment, a deposit which is gradually removed during the declining and low stages of the river.

The filling shown by the soundings of 1877, then, is not to be considered a permanent deposit, but owes its existence to the length of the high-water season, to the source from which the high waters came, and the time which had elapsed after the passage of the summit of the flood wave before the date of the soundings.

The order of the Chief of Engineers led to an examination of the records for information bearing upon the construction and purpose of the works near Venice, for those works were chiefly planned and executed by the city of Saint Louis. (The results of this examination are given in the form of a historical memoir of the harbor of Saint Louis.) In all matters touching upon the acquisition and exercise of legal rights the documents have been quoted at length either in the text or as appendices. Upon matters of professional opinion the very words of official reports are given in some cases; in others an epitome of the arguments. Matters of fact are usually given by quotations.

Accompanying the memoir is a small map, showing the Mississippi River from the Chain of Rocks to Carroll's Island on a scale of $\frac{1}{80000}$. The broken lines in front of Saint Louis, above and below the central part of the city, show the old banks. The spaces between them and the full lines have been reclaimed from the river. The dotted lines show the lines of the proposed improvements on each side of the river, the lines on each side of the channel being the limits of encroachment at low water, and the corresponding lines on each side are the limits of permanent buildings or structures; in other words, the high-water limits.

With the facts and arguments given at length in the memoir, the summation upon the question of "damages, if any, done or to be done," &c., can be made in a few words.

Damages done must be by works constructed since 1872, for such as was due to the operations of Lee in 1839 was covered by the receipt in full given by the Madison County Ferry Company when paid the \$3,000 compensation in 1841, under the provisions of ordinance No. 805, "for all damages done them by the United States or by the city of Saint Louis, or that may hereafter be done them by the authorities aforesaid in the prosecution of the works designed to improve the harbor of Saint Louis."

The "works designed" were the longitudinal dike extending from Kerr's Island to the head of Bloody Island, with such cross-dikes as were deemed necessary or expedient. The plan and location of these works were definite and well known when the receipt was given.

The Madison County Ferry Company was originally chartered February 3, 1840, for 10 years, which charter was continued in force for 20 years "from the date of the pas-

sage of this act" by act approved February 11, 1847, and was made perpetual by "act to recognize the existence and authorize the continuance of the Madison County Ferry Company," approved February 22, 1854, which was further amended and confirmed by an "act to amend the charter of the Madison County Ferry Company," approved February 20, 1867.

The ferry company owns the whole front above the Madison County line except a portion sold by the ferry company to the Venice Elevator Company; therefore all claims for damages done or to be done by works constructed or to be constructed upon or within the line of Lee's dike seem to be effectually barred by the payment in 1841. In confirmation of this view, the terms of the joint resolution of the Illinois legislature, passed February 9, 1849, secure the privilege of constructing a roadway on the cross-dike to the ferry company, plainly implying that, so far as the ferry company was concerned, the city had full power over the use of the area behind the dike, for the Madison County Ferry Company is "authorized to construct a roadway on the cross-dike marked V, and the Illinois Coal Company is authorized to construct a roadway on cross-dike marked W," but said roads must be constructed "so they will not injure said works, and are to extend to the river and be free to the public forever as highways."

The dike designated in the resolutions as "the cross-dike marked V" was built by the city of Saint Louis, and its remains are still visible. In 1861 the broad foundations of the dike were exposed from the shore to within 200 feet of the line of Lee's dike.

The ferry company did not avail itself of the privilege of building a roadway upon the dike, but did build a landing a considerable distance above it. The resolutions specify the location of dike V as running "from the line dividing Madison and Saint Clair Counties to said main dike." The map shows the dike about 60 feet below the county line, the explanation being that the line is in dispute, and one survey locates it at the dike and another as shown by the map. Neither did the ferry company extend their landing to the river as required by the resolutions, for the landing is 325 feet east of the line of Lee's dike. The cross-dike V, shown on Kayser's map, extends 150 feet beyond the general line of the longitudinal dike; and, strictly speaking, the landing should have been at the outer end of this pier-head, or 475 feet west of where it now is. If the ferry company had complied with the terms of the legislature, and their landing had been impaired by subsequent works, they clearly would have been entitled to damages; but not having so complied they, by their own neglect, have contributed to the result, and cannot establish a claim for damages, because it is clearly impossible to ascertain what the effect would have been upon their landing if located in the prescribed place.

The extension of Long dike (the same as the dike marked W, referred to in the resolutions) by the United States is the only work actually done that was not distinctly provided for by the payment in 1841, and also by the resolutions of 1849. The raising of the old dike, being wholly within the line of the old longitudinal dike, cannot be called in question by any proprietary interest in Venice. Dike W, of the Kayser map, referred to in the joint resolutions, extended 240 feet beyond the line of the longitudinal dike or dam. The extension of the dike made in 1873 by the United States was 420 feet beyond the line of said longitudinal dike, or 180 feet outside of the pier-head provided for by the joint resolutions. At low water the visible part of the dike as it now exists terminates very nearly where the pier-head of W was to be.

It is not possible to say that this extension has impaired the landing of the Madison County Ferry, for neither the wagon nor car transfer landings are where they should be according to valid agreements, being several hundred feet within the line of Lee's dike. Moreover, the situation of those landings, under the lee of Bischoff's dike, and behind the point of the bar formed under that dike (this bar is prolonged as a ridge under water, of which the crest is exactly over Lee's dike), favors the conclusion that the impairment of the landings at Venice is due to the dike above, and not in any appreciable degree to the moderate extension of the one 3,200 feet below. For the ferry landing being very nearly equidistant from the two dikes is much more under the effect of the upper than of the lower, and the upper dike was expressly authorized to be built and maintained by the acceptance on the part of the ferry company of the terms prescribed by ordinance No. 6817 in 1869 (quoted in the accompanying memoir), at which time the ferry company was under its present management. In fact, it is stated that the ferry company purchased the land at the eastern end of the dike after the dike was built in order to be able to furnish the desired privilege of maintaining said dike in exchange for a valuable privilege on the Saint Louis side of the river.

The Venice elevator, being built on ground purchased from the ferry company, took its title subject to all the previous legal acts and obligations of that company, and is precluded from claiming damages for failure to be accessible from the river, because it was built in an inland position, the lawful river front being, by the act and agreement of the party from whom the ground was purchased, 400 feet west of that part

of the main building nearest to that front, and 350 feet west of the elevator "leg." The elevator being 400 feet above the ferry landing is so much nearer Bischoff's dike, and the more liable to be behind the bar under said dike; injury from this source is a contingency also covered by the act of the ferry company before the sale of the ground to the elevator company.

So far as the works done are concerned, the answer must be that no damage has been done by works actually constructed by the United States "to the riparian owners of lands or the improvements thereon," at or near the town of Venice.

As to damages to be done by contemplated works, everything depends upon what works are contemplated. The only information upon this point is that contained in the report of the Board of Engineers of April 13, 1872. (Report of Chief of Engineers for 1872, page 364.)

"The board believe that the ultimate demands of commerce will require that, within the limits above specified, the eastern bank of the river will have to be brought to a line parallel, or nearly so, to the opposite city levee, and at a distance from it at low water of not over twelve or fifteen hundred feet, and rendered permanent throughout the entire distance. The present demands are that, within the upper portion, namely, from Bischoff's Dike down to the East Saint Louis levee, the channel of the river should be confined within the limits specified. To do this the board recommend the raising and extension of the two Venice dikes and the Long Dike, which it is estimated will cost \$171,586, to which 15 per cent. should be added for engineering and contingencies, bringing it up to \$197,323.90.

"The board think it possible that an additional dike will be required between Long Dike and the head of Bloody Island, but they believe it best to wait and see if the large indentation will not be at least partially filled by sediment from the river before building it.

"The board believe that when these dikes shall have been built as proposed, the demands of business will soon cause the riparian owners to fill in between them and to connect the ends of the dikes by a continuous levee, thus giving a permanent river bank as demanded."

In the accompanying memoir an extended argument against the prosecution of this project in its present form is given. In addition to what was then said, the presentation of the complications likely to arise and the claims for damage which will be made if it be carried out, justify the recommendation that the subject be reopened.

After the report of the board was made, General Reynolds submitted a sketch accompanying his letter to the Chief of Engineers of September 17, 1872, showing lines that would avoid the difficulties which it had then been discovered would attend the carrying out of the recommendations of the board. Those lines were drawn in total ignorance of the location of Lee's works, as it has since been learned that Lee's line was quite near that of Reynolds's. (The two are shown on the large scale-map.) Lee's line in blue and Reynolds's in dotted red. It will be noticed that Lee's line so far as constructed is parallel to the city front as now established.

Considering the sanction that has been given to Lee's line by compromises, concurrence of engineering opinion, and legislation, I recommend that it be permanently adopted as the east limiting line of the river. So far as works to be done by the United States are concerned, they should be upon or behind it, leaving it optional with the city either to retain its present front with all the disadvantages attending it, or to build out to the red dotted line of the Reynolds sketch.

Whether the city line be advanced or not, the proposition here made insures a gradual contraction of the river from its natural width at Bissell's Point to its regulated width in front of the central part of the city.

The portions of Bischoff's and long dikes extending beyond the Lee line I would allow to remain, but would cease to repair, and leave them to sink gradually as far as they will. If the city line remains as it now is, these dikes would help to maintain navigable water on the city side below North Market street, and would not probably materially interfere with landings in front of Venice when such landings are advanced to Lee's line, even if kept near their present height. If the city line be advanced, the dikes, when settled below low water, will serve to prevent the water becoming excessively deep on the east side, and serve as equalizers of depth, as well as to guard the foot wall of the east bank from excessive scour.

As the first and most appropriate step in the execution of the improvement of the upper harbor, I would recommend the completion of Bischoff's dike as a high dike and embankment from the Chicago and Alton Railroad to the river at the up-stream prolongation of Lee's line, the ferry company, in consideration of the right of way and undertaking to maintain the embankment after completion by the United States, to have the right to use such embankment for railroad tracks and transfer facilities. I would also propose, as the second most appropriate step in the improvement, and as a fair compromise of all equitable claims on the part of the Madison County Ferry Company for the interruptions and temporary disadvantages attending a change of landing, the extension of the wagon road at Ferry street, Venice, at a level grade, 60 feet wide on

top, from the top of the present bank to or near Lee's line, thence to descend by at least as easy a slope as the present landing to a wall or pier-head 7 feet above low-water mark, the same to be a public road forever, as prescribed by the terms of the resolutions of the Illinois legislature in 1849 for the roadways to be constructed on dikes V and W. The cost of these works together may be estimated at \$100,000, which is to be compared with the unexpended part of the estimate made by the Board of Engineers, which is \$197,323.90, less \$36,341.85, equal to \$160,982.05, or a saving of nearly \$61,000.

Very respectfully, your obedient servant,

Col. J. H. SIMPSON.

Corps of Engineers, U. S. A.

ROBT. E. McMATH,

Civil Engineer, Assistant.

HISTORICAL MEMOIR OF SAINT LOUIS HARBOR AND THE WORKS FOR ITS IMPROVEMENT,
BY MR. ROBERT E. McMATH, ASSISTANT ENGINEER.

The situation of Saint Louis upon a convex bank has been several times mentioned as an instance of want of foresight, or judgment, on the part of its founders; for it is said the first demand of a maritime city is deep water along its wharves, and for deep water to exist permanently along a convex shore is contrary to the nature of channels of running water.

If it be borne in mind that the line of deepest water is also the location of the swift-est current, it may appear that in the selection of a site for the new settlement the advantage of a dry, permanent bank of moderate elevation, with back country affording a favorable site for a residence town, outlying fertile lands for cultivation, and a commanding position for defense or trade, was by no means impaired by the fact that the slackened current on a convex shore afforded easy landing to the batteaux, which, to the eye of the pioneer, represented the perfection of river craft. Moreover, we are not to suppose that Laclède or those with him were acquainted with hydraulic theories; but that they were content to take things as they found them, without speculating why the water they found deep enough should in the future become shoal. That the water was then deep we have the statement (in Saint Louis, the Future Great City of the World, Centennial Edition, page 10) "that the Mississippi was very deep, but a great deal narrower than it is now, as it is stated by the old inhabitants that persons could converse with each other across it without effort." Now, as it was stated in 1849 (see Appendix L) that the river had widened about one thousand feet within this (the 19th) century, it is probable that at the time of the first settlement in 1764 the width of the river was fully one-half of a mile, whence it would appear that whatever the pioneers may have lacked in judgment in selection of the site, they made up in the vigor with which they spoke in (or perhaps about) their town.

Leaving the age of tradition we have evidence that in 1803 the river was 3,200 feet wide opposite the center of the city (Olive street). Bloody Island had no recognized existence, and the shore just above the town was 1,800 feet farther west than now (at the mouth of Rocky Branch) and below the town 1,200 feet farther west than now (at the mouth of Mill Creek near Miller street.) If a chord be drawn between these points, Dock and Miller streets, on an old map, a curved segment is cut off having a versed line of 3,200 feet (at Carr street), the chord being about three miles in length. As the then topography presented a slight ridge about where Fifth street now runs and a depression in the vicinity of Eighth or Ninth streets, it is plain that to the pioneer mind the short line of rear defense required was more likely to decide upon the selection of a site for the new settlement than any consideration "of its adaptability as the site of a great city," or "because of its natural pleasantness and beauty."

That the location has proved to be well adapted to the needs of a great town is but an instance "of men building wiser than they knew." The insignificant bearing which the consideration of harbor facilities could have had, may be gathered from the fact that in 1788 the arrival of a fleet of ten batteaux formed an epoch in the chronology or tradition of the settlement known as "*L'année des Dix Batteaux*."

As to the actual condition of the harbor at the time of settlement Auguste Chouteau is quoted (Western Annals, page 122) as saying, "No Bloody or Duncan's Island then existed. Directly opposite the old market square" (between Market and Walnut streets) "the river was narrow and deep, and until the commencement of the present century persons would be distinctly heard from the opposite shore. Opposite to and below the town was a heavily timbered island separated from the Illinois shore by a slough." (Old bed of Cahokia Creek, the island was for many years called Cahokia Island, now Cahokia commons.) "The only ferry was for a long time from Cahokia below the island to the Missouri shore, near the United States arsenal." (Saint Louis barracks in 1878.) The want of a bridge across Cahokia Creek at that time forbade any attempt to maintain ferries opposite the new town. At that time Dr. Piggott (in historical lecture before Literary and Historical Society of East Saint Louis, August 4, 1871) says: "Part of Bloody Island, and the dike and ponds in its vicinity, was bottom land covered

with heavy timber, the favorite camping-ground of Indians on missions of peace or hostility.

The same authority states: "That the main channel of the Mississippi in 1800 ran nearly straight from the chain of rocks (about ten miles above center of city) toward and close to the old western boundary of Cabanne (Cabaret) Island, and from thence striking the rocky shore of Missouri above Saint Louis, near where the Sturgeon Market now is; thence running deepest against said rocky shore to Market street, below which a sand-bar formed, which grew into what is now called Duncan's Island, causing the current to deflect to Cahokia Island, and carried off a great part thereof. Meanwhile accretions accumulated on the west side of Cabaret Island. This caused the current to carry off a great deal of the Missouri shore, and formed what was called Sawyer Bend, above what is called Bissell's Point. In the fall of 1798 a sand-bar was formed in the Mississippi. * * * It increased rapidly and soon became an island covered with willow and cottonwood." In 1817 this island received the name of Bloody from being the dueling-ground of Saint Louis.

During the earlier years of its history Saint Louis was but a trading-post, where the beginning of the artificial wants of a savage people were satisfied by the barter of furs and the few products of Indian industry for the knives, hatchets, and beads, produced by civilization. So long as the Indian occupied the land the trade must necessarily have been small. Reavis quotes (page 7, *Future Great City*): "In 1790 a Saint Louis merchant was a man who in the corner of his cabin had a large chest which contained a few pounds of powder and shot, a few knives and hatchets, a little red paint, two or three rifles, some hunting-shirts of buckskin, a few tin cups and iron pots, and perhaps a little tea, coffee, sugar, and spice. There was no post-office, no ferry over the river, no newspaper."

At the time of transfer to the United States in 1804, the town consisted of two long streets, La Rue Principale (First or Main street), La Rue de l'Eglise (Second street), and a few houses on La Rue des Granges (Third street). There had been no official mail, no post-office. The occasional arrival or departure of a boat was a marked event in the monotony of life, and caused, it is said, the gathering of a crowd. But those who of late years have witnessed the gathering of similar assemblies at the landings of small river towns at the coming of the daily packet, will be inclined to consider that this statement proves the idleness if not indolence of the inhabitants, rather than the infrequency of the events. Still, charity requires us to say that the return from or departure of the most enterprising and industrious men in the community on a voyage that would require many weeks or even months might well collect their friends and relations to give the last good wish to departing or greeting to returning voyageur. Much of toil and no small degree of danger from savage foes and from more wicked pirates, as well as risk of death or disease on the way, which human hand did not produce and could not avert, attended these voyages. The only known propelling power other than the uncertain wind which seldom availed to stem the current for any considerable time or distance, was human muscle applied to paddle, oar, setting-pole, or cordille. A voyage under such conditions was no small undertaking; the return trip from New Orleans was considered expeditions if made in ninety days.

From what has preceded, it is apparent that the early requirements for harbor facilities were amply satisfied by the natural state of the river in front of the town. In 1798 the first symptoms of future trouble in Saint Louis Harbor appeared in the formation of the sand-bar which became Bloody Island. In 1810 this bar was still small; in 1818 the land surveys show a bar or island nearly equal in area to the present island, but lying some one-fourth of a mile further up stream. In 1819-'20 the channel eastward of the bar widened so rapidly that the site of the proposed town of Washington, laid out in 1819, had mostly disappeared in 1820. The first directory, published in 1821, speaks of a bar, dry at low water, below the town as one of the chief sources of supply for firewood.

While this change in the natural condition of the harbor was in progress, preparing the way for its injury if not total destruction, changes in the artificial condition were preparing demands for improved harbor facilities.

In August, 1817, a new epoch in the history of Saint Louis was marked by the arrival at the landing of the pioneer steamboat Pike. This event may be said to mark the epoch, but it did not of itself form it. In the affairs of men events march together as marshaled by intelligence. The steamboat came after rather than before the spirit of enterprise had been infused into the old town by the new blood brought in after the change of government. Enterprising emigrants made steamboats profitable, and therefore the inauguration of the age of steam possible. On the other hand, the advent of steamboats made agriculture and trade profitable, and thereby encouraged and extended emigration and all its results. Neither can be said to be cause or effect, antecedent or consequent; they are correlated.

By like correlation the impairment of the natural harbor on one hand, and the growing demand for harbor facilities on the other, compelled the comparatively early adoption of extensive and costly plans of improvement, which neither cause alone

could have done. For no small city, as was Saint Louis, could or would have undertaken a task of such magnitude unless under stress of necessity.

The growth of business on the river kept pace with the increase of population, extending to new streams and nearer the head-waters, as emigration brought in population to produce material for export or to need supplies. Statements regarding the earlier years are conflicting. Reavis (page 32 "Future Great") gives August 2, 1815, as the date of the arrival of the steamboat General Pike. The "Annals of the West" gives August 2, 1817, as the date, agreeing as to the name of the boat and that of its master, Jacob Reed. The two authorities also agree on the date of arrival of the second boat, the Constitution, R. P. Guyard master, on October 2, 1817. The "Annals" say explicitly that the two arrivals were in the same year; therefore the weight of evidence favors the date of 1817 for the first arrival. In 1818 the same authority says there were several arrivals. In 1821 the first directory of the then town (incorporated as a town November 9, 1809; as a city in December, 1822) states: "That the value of imports was upwards of \$2,000,000 annually, the commerce by water being carried on by a great number of steamboats, barges, and keel-boats, which center here after performing the greatest inland voyages known in the world."

The growth of trade is best shown by the following table taken from official sources:

Year.	Number of barges.	Number of steamers.	Tonnage.	Number of entries.	Wharfage.	Remarks.
1817.....		2		2		
1824.....					686 37	
1825.....					197 07	
1826.....					611 60	
1827.....					1,607 71	
1828.....					1,268 17	
1829.....					1,350 97	
1830.....					1,245 38	
1831.....	60		7,796	432	1,594 99	
1832.....	80		9,520	508		
1833.....	99		12,222	573	4,831 89	Estimated.
1834.....	110		13,173	607	3,236 90	
1835.....	121		15,470	803	5,151 32	
1836.....	144		19,447	1,355	9,485 26	
1837.....	195		22,794	1,484	10,649 43	
1838.....	162		24,361	1,364	10,441 97	
1839.....				2,095	11,716 76	
1840.....					13,451 96	Estimated.
1841.....					15,187 16	
1842.....					14,115 19	
1843.....					17,407 86	
1844.....					20,739 25	
1845.....	346	2,100	358,045		22,449 23	Possibly the number of boats given is the number of entries, the record does not specify.
1846.....					25,210 44	
1847.....					31,231 05	
1848.....					35,886 16	
1849.....					33,701 72	
1850.....					46,912 26	
1851.....					47,064 35	
1852.....					55,506 69	
1853.....					58,402 87	
1854.....					60,069 99	
1855.....					62,613 46	
1856.....					74,061 68	
1857.....					72,345 72	
1858.....					64,808 18	
1859.....					69,615 72	
1860.....					67,544 66	
1861.....					28,635 85	
1862.....					43,997 36	
1863.....					54,152 90	
1864.....					72,290 97	
1865.....	1,141	2,767	1,229,826		84,384 60	Registered tonnage and arrivals.
1866.....	1,142	2,972	1,227,078		78,226 88	
1867.....	947	2,478	1,086,340		66,293 45	
1868.....	1,133	2,338	1,055,795		85,965 43	
1869.....	1,240	2,789	1,225,443		92,365 72	
1870.....	1,195	2,796	1,166,889		92,524 91	
1871.....	1,165	2,574	1,653,899		70,470 95	Receipts and shipments make up tonnage.
1872.....	1,485	2,346	1,669,201			
1873.....	1,020	2,316	1,593,311		59,774 99	
1874.....	951	2,332	1,440,090			
1875.....	743	2,201	1,302,620			
1876.....	683	2,122	1,288,980			
1877.....	660	2,150	1,242,155			

The above exhibit will show the growth and fluctuations of the trade as well as can now be shown. The rate of wharfage was not uniform, and was reduced to a nominal rate in 1874.

The earliest authentic information upon the condition of the harbor when its improvement became necessary is contained in the report made by General Gratiot in 1834, a copy of which is given as Appendix A.

A report of the street commissioner of Saint Louis, made in 1836, was printed and sent to the Engineer Bureau, and a memorial was addressed to Congress asking for an appropriation for the removal of the sand-bar obstructing the harbor of Saint Louis. Probably in consequence of this memorial an appropriation of \$15,000 was made for the construction of a pier to give direction to the current of the Mississippi River near Saint Louis.

In the report of the Chief of Engineers, November 30, 1836, it is said that no officer being available for the duty, the execution of the work was offered to the authorities of Saint Louis and declined. Later, Capt. H. M. Shreve was directed to take charge of the work, draw up a project for the construction of the pier, and nominate a suitable person to superintend the construction under Shreve's instructions. Shreve reported that the most favorable season had passed, and that it would be well to defer operations until June or July of the next year. He also said the appropriation was too small to secure results, and recommended that it be increased to \$50,000. In December the city council withdrew its refusal to execute the work, and pledged itself to afford every facility in its power to aid the work. This offer was not accepted.

The city council adopted a memorial to Congress, late in 1836, asking for an additional appropriation, in which mention was made of the recession of the opposite shore, as well as an increase of the bar in front of the city, and fears were expressed lest the harbor be greatly impaired, if not totally destroyed, unless speedy help was afforded.

The mention of the recession of the opposite shore indicates that it had been discovered that the problem involved much more than the simple removal of the sand-bar.

During the winter of 1836-'37 an additional appropriation of \$35,000 was made, making the amount available \$50,000. Nothing appears to have been done by Shreve, even in the way of a plan for the work, for General Gratiot, the then Chief of Engineers, met the city authorities by appointment, June 9, 1837, and stated that a survey must be made extending to the mouth of the Missouri. This survey would be the basis for plans which would probably be similar to those successfully tested on the Hudson. Early in August Lieutenants R. E. Lee and M. C. Meigs, Corps of Engineers, United States Army, arrived and commenced the survey. A report and plan was submitted by Lee, December 6, 1837. See Appendix B. Lee's estimates were for—

Dam at head of Bloody Island to main shore.....	\$63, 574
Dike at foot of Bloody Island.....	80, 680
Protection of west side of Bloody Island.....	14, 300
Total.....	158, 554

Though Lee makes but incidental mention of the enlargement of the channel east of Bloody Island, his plan provided for the closing of the chute; but he does not seem to have shared in the opinion that the need of its closure was urgent, for he finally preferred an indirect mode of turning an additional volume of water to the west of the island. In 1838 General Gratiot is reported as having refused to recommend further appropriations, but no reason was assigned for his refusal. This adverse action on the part of the Chief of Engineers seems to have aroused the city to the necessity of taking a more direct interest in the work.

During the early part of Lee's administration it does not appear that the city furnished any material assistance other than the privilege of obtaining rock from the city quarry. October 1, 1838, the board of aldermen asked Lee whether the \$50,000 would be sufficient to complete the works contemplated that year; if not, what further sum would be required; and also whether it was important that the work should progress before another appropriation could be made by Congress. Lee replied that the appropriation would be expended by November 1, and that, though not completed, the dike from the foot of Bloody Island was beyond reach of injury during the winter, and while it was not essential that the work should progress, yet it was inexpedient that any part of the season favorable for work should be lost; about \$15,000 could be used to good advantage. The council, on October 30th, passed a resolution authorizing the mayor to borrow \$15,000 and placed the money subject to the draft of Lieutenant Lee, the same to be refunded out of the next appropriation. The money was borrowed and became a subject of correspondence until August, 1839. It seems that the Engineer Bureau did not accept the loan; but the money was finally expended as a contribution by the city to the work under the general direction of Lieutenant Lee. From Lee's report of October 21, 1839 (see Appendix D), it appears the work was

under his direct supervision until stopped by an injunction. This injunction was probably removed, as the mayor, on October 29, 1839, informed the house of delegates that work had been resumed under the superintendence of Henry Kayser, with instructions to carry out the plans of the United States engineers. The boats and tools owned by the government were loaned to the city for use in the work.

From the statement in Lee's reply to the inquiry of the aldermen already cited, that the appropriation would be exhausted November 1, it appears probable that the report dated October 24, 1838 (see Appendix C), covers nearly, if not quite, all the work actually done under the authority of the appropriation; which work, as appears by the report, was limited to a pier or dike from the foot of Bloody Island, parallel to the Missouri shore; the work at Kerr's Island being constructed with funds furnished by the city of Saint Louis.

The feeling in favor of the city prosecuting the works was not unanimous, for November 30, 1840, a resolution passed one branch of the common council to the effect:

"First. That the improvement of the rivers of the United States is justly the exclusive province of the general government, and no city or State bordering on such river should be called on to make improvements which are national, and in which citizens of several States have a common interest.

"Second. That the mayor memorialize Congress for an appropriation sufficient to complete the work already commenced by the United States for the improvement of the harbor of Saint Louis."

Considerations of policy, doubtless, prompted these resolutions, for they were inconsistent with the acts of the city which, at this time previously and afterward, was engaged in the prosecution of the very works which are here described as national and in which citizens of several States had an interest, as will appear from the following statement of expenses incurred by the city of Saint Louis for the harbor improvement since the abandonment thereof by the United States Government.

In 1839, under the direction of the United States officers, for the construction of a dike above Brooklyn.....	\$7,599 55
Under the direction of the city engineer on the same dike	5,580 71
In 1840, purchase (at sale of United States property) of four transportation boats, quarrying tools, pile-drivers, &c.....	3,990 35
Under the direction of the city engineer for the construction of four oblique dikes and dike above Brooklyn.....	6,738 71
In 1841, during the winter, under the direction of the city engineer, for repairs of the main dike opposite the city.....	786 37
During the summer for the construction of the southernmost cross-dike opposite the city	3,280 15
In 1842, sinking the <i>Troubadour</i>	353 00
Preservation of boats since their purchase.....	194 70
<hr/>	
Making a total.....	28,523 54
Credit by sale of sundry articles.....	\$318 66
Credit by hire of scows	503 48
<hr/>	
Balance	822 14
<hr/>	
Balance	27,701 40
Of which the balance of appropriation turned over to the city by the United States was.....	4,437 64
<hr/>	
Leaving paid by the city.....	23,263 76

The balance, said to have been turned over by the United States to the city, was not part of the \$7,599.55 expended under direction of Lee in 1839, for the mayor, at request of the council, requested the transfer of the balance in October, 1840, and under date of July 6, 1842, the city engineer transmitted to Colonel Totten the vouchers and abstracts showing how the money had been expended.

After the above statement was made the works seem to have made little or no progress. In 1842, old works were repaired at foot of Bloody Island, and two cross dikes were built under Ordinance No. 1043, at a cost of about one-half on an appropriation by the city of \$6,455.67.

A report of the city engineer, made August 8, 1842, says, "Formerly the main current, after passing west of Cascaret (Cabaret) Island, kept on the Missouri side to Bissell's Point, the shoal water being along Kerr's Island. During the last two years this has changed and the current coming out of Sawyer Bend strikes over to the lower end of Kerr's Island, just above the head of the upper main dike." The causes of the change were said to be unknown. This report gives the first intimation found on record of the real or apprehended loss of the deep water which had previously existed along the upper part of the city landing. The object up to this time seems to have been the removal of Duncan's Island and the bar extending under water from its head

toward the foot of Bloody Island. This object having in a great measure been secured and the danger to the upper landing not having developed itself so far as to compel attention, the subject of harbor improvements seems to have been dropped by the city; for on November 1, 1843, the total disbursements on account of harbor are stated at \$27,865.64, an increase of \$4,601.88 over the statement of April 1, 1842. The succeeding years to 1847 witnessed but trifling disbursements. In August, 1843, the city engineer estimated the proportion of water flowing west of Bloody Island as $\frac{1}{7}$ of total volume. A survey was made by Coote and Winklemeier for the city, in 1843, but no report was made, as the United States engineers were also making a survey. The report of this survey was made by Capt. T. J. Cram, February 3, 1844.

Captain Cram, after stating that the abrasion of the banks east of Bloody Island had been 1,050 feet since 1814, and 300 feet since Lee's survey in 1837, and considering at length the causes operating to conserve or destroy the harbor, the nature of the river bed, what works had been proposed and constructed, and with what effect, gave his views as to the objects to be arrived at, and how to be accomplished, for which see Appendix F.

Cram said that $\frac{1}{10}$ of the water passed to the west of Bloody Island, which is quite near the proposition of $\frac{1}{7}$, quoted from the city engineer above, falling short by $\frac{1}{3}$. He discussed and estimated the cost of several plans, giving preference to the plan proposing the revetment of Sawyer Bend, and of the Illinois shore behind Bloody Island, and the construction of a pier at Chain of Rocks to throw additional water east of Cabaret Island, which channel at that time carried about $\frac{1}{2}$ of the water.

His second choice was to force all the water to pass west of Bloody Island at all stages below five feet (7' 6" present standard) above low water. To accomplish this he suggested four plans, of which he preferred a snag dam. This snag dam was a favorite of Captain Cram's superior, Lieut. Col. S. H. Long, and somewhat naturally was the plan indorsed by that officer in his letter transmitting Cram's report to the Chief Topographical Engineer, Colonel Abert. The plans of Captain Cram were reviewed by a Board of Engineers composed of Lieut. Cols. J. Kearney and S. H. Long. A second report by Captain Cram, made after the flood of 1844, is given as Appendix G, and the essential parts of the separate reports of Long and Kearney are given as Appendices H and I. These reports were occasioned by the appropriation in 1844 of \$25,000 for "the removal of obstructions in the harbor at Saint Louis." Owing probably, to diversity of opinion as to plan, no work was done under this appropriation. In 1845, Cram made an additional report. See Appendix J.

The fact of the appropriation being available served to keep the harbor matter under discussion. The report of the city engineer, made March 16, 1846, states that in the winter of 1842 the lower part of the harbor was so obstructed by bars that the ferry-boat was compelled to land at the foot of Vine street. In the winter of 1845-'46, although the water was two feet lower than had ever been known before, the boat could use her usual landing at the foot of Market street, showing a decided improvement instead of impairment of the wharf front, as had been charged by parties hostile to the plan of the city in extending dikes at Hazel and Mulberry streets. He further said: "The improvement of the harbor requires—first, a regular shore on the Missouri side, which in time will be afforded by the improved levee; second, a regular and nearly parallel shore on the Illinois side; third, regulation of the bed of the river above the city so as to direct the water into the channel under favorable conditions. The first is the work of the city; the latter two are and should be in the hands of the United States." A conference was held between the city authorities and Lieutenant-Colonel Long in 1846 concerning the division of the work and the application of the appropriation. Colonel Long's report is given as Appendix K.

The deterioration of the upper harbor proceeded until at low stages boats from above could not come to the central part of the city. The Alton packet in January, 1847, was compelled to land at the upper ferry. The bar was reported to touch the Missouri shore at Montgomery street.

Notwithstanding this indication of a coming necessity for further effort, the mayor in his message of May 11, 1847, questions whether the city should on its own resources go further in the matter of harbor improvements, arguing that the importance of Saint Louis as a port rendered it peculiarly the province of the general government to extend, improve, and maintain the harbor. This claim was doubtless in part based upon the importance given to Saint Louis at that time as one of the chief points whence supplies were drawn for the armies then operating in Mexico.

Congress at this time seemed entirely willing to make what at the time would have been considered liberal appropriations for this harbor and other public works, but all bills of the character were consistently vetoed by President Polk. A river and harbor convention was held in Chicago in July, 1847, to which the Saint Louis delegation presented a carefully prepared report, written by Thomas Allen. As a result of the votes, the question of internal improvements became a political issue of no little importance in the Northwest and West.

Additional appropriations being unobtainable, inquiry was made as to what had

become of the unexpended appropriation of 1844. It was reported that the chief of the bureau, in accordance with Lieutenant-Colonel Long's recommendation (see Appendix K), proposed using this balance for the construction of a dredge for use in the harbor. This intention was treated with much indignant ridicule in the papers of the day, in which connection it was charged that a large proportion of the government appropriations had been wasted in surveys, equipment, and in employing topographical engineers. A correspondence was had on the subject between the Secretary of War, the Chief Engineer, and the city authorities. The opposition to the dredge-building project was so strong that a petition was addressed to the President requesting him to order that the money should be expended for the revetment of the western shore of Bloody Island. This petition was disregarded, and further effort to secure the expenditure of the money was made under the provisions of Ordinance No. 1954, of which section 1 authorized the issue of \$75,000 in bonds, "provided the United States Government shall give assurance by the 1st of March next (1848) that it will apply the balance of the appropriation as set forth in the second section."

Section 2 directed the mayor to forward a copy of the ordinance to the proper department with a request that the balance be applied, as soon as practicable, "to the construction of a stone dam across the eastern channel of the Mississippi River opposite Saint Louis, at the head of Bloody Island, at such location and in such direction as may be deemed best." Said section also gave assurance that the \$75,000 in bonds and \$15,000 to be furnished by the Saint Clair Ferry Company should be applied as set forth in the fourth and fifth sections: that is, seven-fifteenths of the proceeds of the bonds should be used for the continuation of the above dam at the head of Bloody Island after the expenditure of the balance of the United States appropriation; two-fifteenths to be applied to the revetment of the western shore of Bloody Island, and six-fifteenths plus the \$15,000 furnished by the Ferry Company to be used for the construction of a dam across the eastern channel at the foot of Bloody Island.

This ordinance was amended by ordinance 1973 by reading 20th of March instead of 1st, and further by ordinance 1992, which authorized and instructed the mayor to issue the bonds whenever the Saint Clair Ferry Company entered into obligation to furnish \$15,000 for the work, and repealed all of ordinance 1954, relating to obtaining assurance of the co-operation of the United States authorities.

By ordinance 2018 the mayor was authorized to take such steps as he may deem advisable to secure the progress of improvements in the harbor and to procure the expenditure of this balance. This is the last reference to the balance which the city authorities were so anxious to have expended. From all that can now be ascertained, the balance, \$22,709, never was expended.

Looking at the matter after thirty years have passed, it is difficult to say which would have been the more useless expenditure—to build a dredge costing \$18,000 and have a balance of \$4,709 to expend in dredging the shifting sand-bars of the Mississippi, or to expend the whole in constructing a dam at the head of Bloody Island when another dam was being constructed at its foot. Referring to the files of the local papers of this period (1847), it appears that both plans were opposed by argument and ridicule.

The proposition to build two dams when one would have served the apparent purpose was not incorporated in the ordinance ignorantly, but was put in and kept there by the jealousies of the two wings of the city—up and down town. It was anticipated that the dam would eventually be made a roadway and its location would determine the point at which the traffic and travel from Illinois would enter the city, a matter then considered of such importance that when a responsible party offered to give bond to build the upper dike for \$10,000, if the up-town party would consent to defer its construction until two years after the completion of the lower dam, the offer was not entertained. The fear that down-town would by some means defeat the construction of the upper dam as soon as it had secured the advantage due to the prior construction of the lower, led to the persistent demand that the two should be commenced and carried on simultaneously, as provided by section 5 of ordinance 1954.

The mayor at this time, Bryan Mullanphy, did not favor the continuation of harbor improvement by the city. He vetoed the double-dike ordinance 1954, because he did not "see the advisability of narrowing the river one-third in order to secure the advantage of a moderate increase in depth in front of the city."

The history of the harbor at this time becomes identical with that of the works at and in the vicinity of Bloody Island.

The next matter of general importance was the report of Henry Kayser, dated February 26, 1849, given in full as Appendix L.

We have now arrived at the period when a conflict arose between the city and the authorities of the State of Illinois, which, although the contest was chiefly about the construction of the dam across the eastern channel, brought forward questions and led to decisions of courts, and legislative action of such general character as to render the history and final settlement of the controversy appropriate matter for a separate division.

From the message of Mayor Krum of July 3, 1848, we learn that the construction of the lower dam was begun on or about the 16th of May. The Missouri Republican of May 19 noticed the resolution of the Alton city council calling on the government to protect the State against encroachment. In response to this appeal, backed at a later date by similar action of the Quincy city council, and probably sundry individual citizens, the attorney-general of the State of Illinois filed on the 26th day of June, in the circuit court of Saint Clair County, a bill in chancery, wherein the people of the State of Illinois were complainants, and the City of Saint Louis, Henry J. Hall, Anthony Bennett, James Curran, and John Schreiber were defendants, the object of which proceeding was to restrain and prevent the prosecution to completion of the works then in progress.

The above-named action was commenced at the order of Governor French. The petition which prompted the governor's action laid much stress upon the probable injury which would result to interests upon the upper river from the backwater, which would be caused by compelling the whole Mississippi to pass through a channel only 450 yards wide—an argument which did little credit to the intelligence or good faith of the petitioners.

The reasons assigned in the motion for injunction, as stated in the Missouri Republican of June 28, were: First. The dike will destroy the landing of Saint Clair Ferry Company, known as New Ferry. Second. That the dike will be used as a private roadway, interfering with the rights of the State over roads. If built, the Old Ferry can charge for the use of the road by persons not crossing by their ferry. Third. It interferes with navigable waters. Fourth. It would increase the danger of the neighboring bottom-lands being overflowed.

Without entering at length into the numerous documents and reports of this period the record shows that the city was charged by Governor French with asserting a right to build dikes at will without asking permission of the State of Illinois; and also that the city authorities had discourteously refused to give him information concerning their projects when asked, but expressed the intention to carry out their plans. On the part of the city it was claimed, on what was represented to be a decision of an Illinois court, that, with the consent of the owners of the soil on both sides of the channel, a second party had the right to construct the proposed dike as if employed to close a bayou or break through a man's possessions.

The Wiggins Ferry Company, by purchase, were owners of the entire main shore fronting Bloody Island. As this shore had been washed away for an average width of 1,185 feet between 1814 and 1844, as reported by Captain Cram (see Appendix J), an erosion which had probably continued until 1848, the ferry company claimed the right, or rather the city for them, to reclaim the land at least to their original line. The same company, having in 1827 acquired the title to Bloody Island, claimed all the borders of the island to low-water mark. As low-water mark on the east side of the island overlapped the original main shore, it was claimed that the chute was the property of the ferry company, and could lawfully be closed by it or its agents.

The position of the State of Illinois was that the chute was, as a matter of fact, a navigable water, and its use not subject to the will of the owners of the adjoining property.

The legal question Governor French proposed to submit upon an agreed case to Judge McLean of the United States district court, which offer was declined by Mayor Krum. The charge of discourtesy was denied, and the correspondence was published. (Missouri Republican, July 6, 1848.)

A committee was appointed by the city to visit Springfield and confer with the governor, in hope of arranging the matter amicably. The committee reported July 28 that they had laid all the facts relative to the harbor improvement before his excellency, and that Governor French had assured them that they had given him all the information he desired concerning the works in question. The Missouri Republican of August 1 adds that it was understood legal proceedings would be suspended until the governor had examined the matter, and apparently implies that the authorities of Illinois did not observe this understanding in good faith, for it was said the sheriff of Saint Clair County kept guard night and day with an armed posse and cannon planted to rake the dike; a proceeding editorially characterized as "child's play." In regard to this charge of bad faith it is well to observe that it was without foundation. The appearance of an armed posse to enforce an injunction was no violation of an agreement to suspend proceedings, if there had been a formal agreement. Enforcing the injunction was maintaining the *statu quo*. There was cause for the appearance of the posse, for the injunction had been violated.

Upon inquiry concerning the violation of the injunction the city engineer reported that it had been violated by the contractor, but without the knowledge or connivance of any officer of the city. The facts appear to be that at the time the injunction was served the contractors had at the dike several barges loaded with stone, one of which, leaking badly, was unloaded secretly upon the dike. This act was discovered and resented by the citizens of Illinois, resulting in the sinking of one of the contractor's

barges. To prevent the recurrence of similar acts, the governor was clearly justified in ordering the sheriff to enforce the injunction.

As the practical navigability of the chute was claimed and made the chief argument against the construction of the dike, it is worth while to note the statement that the use of the chute for years had been limited to the smallest class of steamboats at high stages, and a few flatboats.

The dike, when construction was arrested, was said to be within three feet of the top of the water. The chute was therefore practically closed at all the lower stages of the river.

The injunction was dissolved by the circuit court and appealed to the supreme court of the State. The case was finally decided about the last of January, 1849. The decision was that a navigable channel is not necessarily the main channel nor its use subject to the will of the owners of contiguous lands.

Upon this decision the city seems to have accepted the situation promptly and applied to the legislature of Illinois for authority to close the channel. The request was very speedily complied with. The joint resolutions granting the desired privilege were passed about February 9, 1849. The following copy of those resolutions is full and accurate (Public Laws Illinois, 1849, pages 238-239):

"Joint resolution relative to the construction of a dike in the Mississippi River opposite the city of Saint Louis.

"Whereas a suit has been pending in the Saint Clair County circuit court, on the equity side thereof, wherein the people of the State of Illinois were plaintiffs and the city of Saint Louis and others were defendants, the general object of which said suit was to restrain and prohibit the said defendants from obstructing the navigation of the Mississippi River by the construction of works designed for the improvement of the harbor of said city; and whereas the general assembly of the State of Illinois is desirous of interposing no objections to any improvements of the harbor of Saint Louis which can be constructed without injury to the general navigation of the main channel of the Mississippi River: Be it therefore

"Resolved by the house of representatives (the senate concurring herein), That upon a compliance with the conditions and terms hereinafter mentioned, the city of Saint Louis is hereby authorized and empowered to proceed with and complete the works now in progress of construction within the limits of this State, designed for the improvement of the harbor of the said city of Saint Louis, in the Mississippi River, according to the ordinances of said city, heretofore passed by the city council of Saint Louis for that purpose.

"2d. The city of Saint Louis shall cause to be filed in the office of the secretary of state for this State a bond or other instrument in writing, good and valid in law, to be approved by the governor of this State, binding the said city of Saint Louis, as soon as practicable, to complete and construct a road or highway over the dam or dike now in progress of construction by said city, opposite the town of Illinoistown, from Bloody Island to the mainland on the Illinois shore; said road to be so constructed as to afford a safe and commodious highway from the Illinois shore to and upon Bloody Island; and further, that the owners of the property on the Illinois shore and of Bloody Island, to and on which said road is to be constructed, will grant the right of way, and undisturbed to the public forever, over said road or highway without any toll or tax therefor; but this easement or right of way shall not extend to any incorporated or chartered company, except the Saint Clair County Ferry and the Saint Clair County Turnpike Company, saving to the owners of said land, commonly known as the Wiggin's Ferry Company, all rights granted and now vested in them under and by virtue of the laws of this State and their acts of incorporation.

"3d. That all the rights and privileges to a ferry landing are hereby reserved to the Saint Clair County Ferry to which they are entitled under the provisions of an act of the general assembly of this State, approved March 2, 1839; and the city of Saint Louis shall file or cause to be filed with the county commissioners' court of Saint Clair County such an instrument in writing, as shall be adjudged sufficient by the governor of this State, as will secure to the said Saint Clair County Ferry either a landing for said ferry on Bloody Island, on the Mississippi River, running out from and fronting as near as may be the landing which said Saint Clair County Ferry had on the mainland of the Illinois shore before the making of said improvements, or that if said Saint Clair County Ferry shall be compelled to condemn a road and ferry landing, according to the provisions of her said act of incorporation, that then the city of Saint Louis will pay the amount of damages that may be assessed in such proceedings and the costs thereof. But said city of Saint Louis shall be obliged to secure to said Saint Clair Ferry the rights she now has and such as may be determined to belong to said ferry by a suit now pending in the Supreme Court of the United States between the said Saint Clair County Ferry and the Wiggins Ferry Company.

"4th: The city of Saint Louis shall, in accordance with the general plan of said works, construct the two dams or dikes from the main Illinois shore to the dam or dike run-

ning from Venice to the head of Bloody Island, and which dams or dikes are designated on the map of said works compiled in January, 1849, by Henry Kayser, superintendent of said works, as W and V, one running from Brooklyn and the other from the line dividing Madison and Saint Clair Counties to said main dike from Bloody Island to Venice. Said two cross-dams to be constructed simultaneously with such main dike and cross-dikes, to be completed within two years from the adoption of these resolutions, and the owners of the Madison County ferry are authorized to construct a road or highway on said cross-dam marked V, and the Illinois Coal Company are authorized to construct a road or highway on said cross-dam marked W, but said road shall be constructed so as not to injure said works, and are to extend to the river and be free to the public forever as highways. And the said Illinois Coal Company may use said road on said dam marked W as a highway for the passage of persons and property, by railroad or otherwise, to and from the main shore to the said main dike. And said Madison County Ferry may use said road on said dam marked V as a highway for the passage of persons and property to and from said shore on the Mississippi River, and any arrangement which the owners of said ferries shall respectively make with the city of Saint Louis respecting said cross-dams or the road thereon as to their construction and the time thereof shall be good and valid: *Provided*, Said arrangement does not interfere with the navigation of the main channel of the Mississippi River or private rights.

"5th. That nothing in the foregoing resolutions shall be so construed as to authorize the city of Saint Louis to impede, obstruct, or in any manner injure the navigation of the main channel of the Mississippi River, nor to impair the sovereignty or jurisdiction of this State, where said improvements are to be made within the territorial limits of this State, nor to invalidate any claim which any citizen of this State may now or hereafter have against the said city of Saint Louis for damages sustained by reason of the construction of said works, or the overflow of water caused by the same. And the governor of this State is hereby authorized to modify the terms contained in the foregoing resolutions, or either of them, if in his judgment such modification shall promote the public interests, or that harmony and good feeling which the general assembly desires to cultivate, and which should subsist between the people of the States of Illinois and Missouri."

The bonds required by the above resolutions having been given, the legal complications between the city and the State of Illinois were finally adjusted. The progress of the several works will be described hereafter.

Duncan's Island, whose origin as a sand-bar, previous to 1835, gave rise to the first demand for harbor improvements, covered the lower part of the city so effectually that the increase of business, incident to the growth and prosperity of the port, had to find room in an extension of the commercial front to the northward, which naturally caused owners of property situated to the southward to ponder the question how they could participate in the benefits which their more favorably circumstanced neighbors were enjoying. So long as the northern part of the city had deep water along its bank by nature, and its continuation was unendangered, the claims of the southern interests were unheeded; but when the northern part of the harbor was threatened, as it was after 1843, the southern interests were able to maintain their claims to share in the benefits of an accessible water-front. Up to 1846 nothing in the way of harbor work had been done south of Market street except the extension of Mulberry and Hazel streets considerably beyond the natural bank of the river.

The report of City Engineer Kayser, February 26, 1849 (see Appendix L), recommended a dike on the Illinois shore below the foot of Bloody Island as the first of a series of works required to continue the rectification of lines opposite the lower part of the city. An act was procured from the Missouri legislature, approved March 12, 1849, authorizing loans for harbor works and making specific provision for the improvement of the harbor southwardly. Under this authority Kayser proposed to construct the dike above mentioned which was intended to promote deposit on the Illinois side, to force the channel out of Cahokia Bend, and to wash away the eastern part of Duncan's Island.

The construction of this dike opposite Duncan's Island was begun in the spring of 1851. The river was then "5,200 feet in width opposite the lower part of the city," and it was proposed to narrow it to 1,800.

Duncan's Island or sand-bar in 1835 extended from Poplar to Trudeau street. At Carroll street the east shore was 1,700 feet east of the present front line; the west shore of the island was 600 and the main west bank of the river 1,250 feet west of the present front. In 1852, chiefly as a result of the efforts to close Bloody Island chute, which had not then fully succeeded, the east side had been removed until the island extended but 500 feet east of the proposed wharf line. The slough or chute between the island and the main shore never was a channel of much importance. Cram in 1845 says it was entirely dry at low water. In the early years the drift-wood that lodged on the head of the bar was an important source of fuel supply to the young city, which

was not well supplied with fuel before improved roads made the abundant coal deposits of the vicinity available. The relics of the habits of those days remain to the present; the residents of Duncan's Island depend still upon the river for their fuel to no small degree.

A small strip of the island was joined to the mainland by cross-dikes at Miller and Lesperance streets in 1852 or '53. The construction of these dikes to a height above overflow at ordinary high stages, and extending them to the high part of the island, which was also seldom overflowed, cut off the inclosed pools in the old chute from connection with the river except for short periods at rare intervals. Consequently the pools remain unfilled to the present time, except so far as sanitary considerations or the needs of the Iron Mountain Railroad have compelled them to be filled at great expense.

The definition of the proposed shore line is now complete, or nearly so, as far down as Anna street, and though it is convex to the river, the deep channel runs close along shore and appears to be permanent. The line was changed several times before constructed. The variable element was the view taken of the relative merits of the channel east or west of Arsenal Island. At one time it was the intention to push out dikes from the Illinois shore, and so force the current to wash away the east side of Arsenal Island to a line passing through it near its middle. Another engineer thought it bad policy not to have fixed upon a straight line of wharf from Plum street to the Arsenal when the improvements at Duncan's Island were planned. South from the arsenal to the lower end of Carondelet it was suggested that the line should be concave, "involving the entire washing away of Arsenal Island and affording an opportunity to make several blocks of ground."

At that time and up to 1866 the chute west of the island was unnavigable. The map of a survey made in 1861 shows a dry bar from the head of the island to the main shore above the arsenal. In 1866 City Engineer Homer advocated straightening the river from the city to Carondelet by a front line passing through the island. About this time the west chute became the main channel, and the wharf line was left as established in 1864, to the then city limits at Keokuk street. As this line ended 750 feet from shore, its adoption involved the widening of the chute by washing away the west side of the island. Several small spur dikes were pushed out from the Missouri shore behind the island previous to 1858, but not far enough to exert any controlling influence, during the time when it was uncertain which plan would finally be adopted. After the extension of the city in 1870, absorbing the old town of Carondelet, the extension of the line in front of the newly acquired territory was brought forward and a project submitted by the city engineer accepting the line as then established by ordinance, nearly in the middle of the channel, affording an opportunity to make many blocks of ground.

The project of making the west chute the permanent channel was acquiesced in by all. The Board of Engineers in their report of April 13, 1872, had indorsed it to the extent of saying by implication that the United States should close the eastern channel if observation showed "danger of the river leaving the channel to the west." Before this proposed extension of the wharf line was formally laid before the city council an ordinance was passed ordering the construction of a dike at the foot of Bryan street. As no necessity was apparent for this dike, it is not unreasonable to suppose that it was moved and passed with a view chiefly to commit the city to the proposed line. Work on this dike was prosecuted so vigorously that the first intimation of its commencement to many was the complaint made by boatmen that the channel was obstructed. This complaint led to a correspondence between the United States engineer officer in local charge, Col. J. H. Simpson, and the city authorities, resulting in a suspension of the work and a reopening of the question of wharf location; but the work had progressed far enough to cross the main channel, which had been along the main Missouri shore. The work being done in the spring, or at the season when the general tendency of the river is to rise, the conditions were unfavorable to the ostensible purpose of the dike, which was to compel the washing away of the west side of the island.

As the stage of water afforded a free discharge of the obstructed water by way of the eastern chute that channel was deepened, and eventually became the main channel, and so it continues to be (February, 1878).

Since the correspondence upon the subject of the Bryan street dike, as published (Report of Chief of Engineers, 1875, pages 497 to 513), does not give the views of the city engineer, the following extract from his report of May 11, 1874, is given in fairness to that engineer:

"In the event government dikes are pushed out from the Illinois shore to secure a channel of 1,600 feet wide, the whole island will not be washed off, while the accretions on the Illinois shore will be of great extent, far exceeding that which will accumulate on the right bank, giving to the east shore a wharf equal to, if not better than ours when finished. The high bluff on the Saint Louis side makes it necessary for our wharf line to be extended eastward as far as possible, which will, of course, lessen the

length of government dikes on the Illinois shore, cheapening the work to the United States, while it will increase it on our side of the river.

"But this seems unavoidable, unless the city forever abandons the wharf frontage for a distance of near two miles along the bluff and very much injures the usefulness of the wharf line in front of the old town of Carondelet, where at present a sort of bay exists, a mile or more long, which has a strong eddy in its entire length. It is apparent, therefore, that our commercial interests are imperative in the demand that from Anna street to the southern limits the wharf line should stand well out into the river, and if the government plans contemplate confining the channel to a width of about 1,600 feet, as it is now confined in front of the main part of the city (or perhaps to one very little narrower), each side of the river will, when the work is done, possess a good commercial wharf. On the other hand, if the wharf line is not set eastward from the bluff bank on the Saint Louis side far enough to permit streets and a wharf sufficiently wide for river commerce and the use of railroads, the interests of the city will be seriously compromised in its commercial features. It is quite possible that the dikes to confine the channel should be made on the east side of the river before this wharf is fully constructed. Of this the government engineers should be the judge."

Growing out of this discussion and the return of the channel to Cahokia Chute, an urgent demand for the closure of that chute was made by all the parties interested; for once all agreed in desiring this action and a survey was made by the United States engineers, in the summer of 1874, with special reference to this matter. Upon the map of this survey a line was drawn to "represent a wharf front that would encroach upon the river-bed as little as is consistent with regular lines." This line, which was about 250 feet nearer shore than that proposed by the city engineer, was finally adopted by the city council.

The construction of a dam across Cahokia Chute has been authorized by Congress, but owing to the small amount of funds provided it has as yet progressed no further than the construction of the abutments of the dam and a partial revetment of the island to preserve the site of the dam.

The act of Congress making appropriations for this dam specifically limits it to a low dam, although it was clearly stated in the report that as such it would necessarily fail to accomplish "all the requirements of the case though securing all that would be desired in the interest of navigation and securing the present purpose of the city of Saint Louis.

Very little has actually been done toward the permanent improvement of the harbor below the arsenal. The plans contemplate considerable reclamations of ground from the river, which must be a slow process. These proposed reclamations extend from above the arsenal to near Dover street, from Fillmore to Stien street, and from Stien nearly to Jefferson Barracks. When complete the alignment of the wharf south will be convex from Market street to Bryan, a distance of 16,000 feet, and concave from thence to Jefferson Barracks, 36,000 feet. Toward the execution of this there is now completed the fixation and reclamation of Duncan's Island and the partial reclamation of the slough west of the island, the dike at foot of Bryan street, and several short spurs extending out from the main shore in the bend opposite Arsenal Island, which have not effected anything worthy of mention. Below Fillmore a dike has been pushed out into the river several hundred feet at the foot of Olive street, at great expense, as the water is from 40 to 60 feet in depth. During the time when the main body of the river passed west of Arsenal Island the eddy which had existed in front of Carondelet was in a great degree filled up. Since the return of the main channel to the east of the island the eddy has not been restored, possibly because the Olive street dike intercepts its path, but more probably the movement of the island down-stream over half a mile in the interim brings the water from the eastern chute to the west bank too low down. Whichever be the reason, and they may work together to produce the result, the destruction of the eddy is favorable to the reclamation of the ground in the bay between Fillmore and Stien streets, and considerable progress has been made toward its accomplishment. Below Stien street the only work done is a low dike, 1,170 feet long, built by the United States in 1873, raised and completed in 1876 to the full extent needed to serve the purpose of its construction as part of the works for the improvement of Horsetail Bar. Its operation in the work of reclamation is an incidental rather than designed utility, which will wholly depend upon the persons or corporations interested in the locality.

On the east side of the river the corrected width is defined only at the Illinois and Saint Louis Railroad dike opposite Chouteau avenue, opposite Marine avenue by the revetment of part of Arsenal Island, opposite Carondelet by the incline of the East Saint Louis and Carondelet Railroad, by the Waterloo Ferry dike, and the coal-dump of the Saint Louis and Cairo Narrow Gauge Railroad. Further down the United States dikes Nos. 2, 3, 4, and 5, for the improvement of Horsetail Bar, with 2,400 feet of partially constructed training wall, are steps toward the definition of a line extending

to the head of Carroll's Island. The widths measured from the Saint Louis wharf to the end of these several works are:

	Fect.
Illinois and Saint Louis coal-dike	1,500
Arsenal Island	1,500
East Saint Louis and Carondelet Railroad	1,050 to 1,300
Waterloo Ferry dike	1,150 to 1,500
Saint Louis and Cairo Railroad coal-dump	1,300 to 1,500
Dike No. 2	2,400
Dike No. 3	2,750
Dike No. 4	2,300

Reviewing the preceding pages the demand for the improvement of the harbor is seen to have passed through two stages. The first, arising out of a felt difficulty in the way of approach to the harbor, has already been considered. The difficulty stood also in the way of all the commerce passing Saint Louis, and therefore the improvement was in no proper sense a local one. The second stage dates from about 1841 or 1843, and is marked by the addition to the former difficulty of an apprehension that the harbor would be entirely lost; not only that the main channel would be to the eastward of the island, but that the Missouri shore would speedily become wholly inaccessible to boats.

It has already been stated on authority of Captain Cram that the volume of water in 1843 west of the island was to that east of it as 10 to 6; in December, 1845 (the same officer says), the quantity running into the city channel is to the quantity running into the Illinois as 1 is to 1.01. Long, in his report of October 18, 1849, gives further information concerning the varying discharge through the two channels. (See Appendix M.) These changes rendered the closure of the chute east of Bloody Island a necessity to Saint Louis, and the hope of being benefited by the misfortune of their rival accounts for the interest taken by Alton and Quincy in the matter of closing the chute much more satisfactorily than the pretended fear of injury from back water caused by forcing the Mississippi to pass through a channel only "450 yards wide." In fact, the prospect had awakened such hopes several years before, not only in pretentious rivals like Alton and Quincy, but even as stated by Colonel Cram in a letter of December, 1877: "The village then called Illinoistown was growing into some importance, and persons interested in real estate there and for a mile or two above had been buoyed up with the expectation that in proportion as the main channel should leave the Saint Louis side and go upon their side their property would be enhanced in value. Indeed, some were contemplating that in the probable event of Saint Louis losing its harbor a rival city would grow up with a good harbor on the Illinois side. The United States, taking the problem of prevention in hand, and then it being followed up by Saint Louis city appropriations, threw a damper upon the high expectations of the Illinoisans. Hence the antagonism to Lee's works," which rose to such a pitch that an injunction was obtained against their further progress. (These injunction proceedings, not being pertinent to the present purpose, have not been traced, but the injunction was probably dissolved.)

These conflicting interests explain the origin of the opposition to the works, and suggest why the city was reluctant to apply to the State for direct authority to prosecute them. Naturally it was supposed that the local jealousies which could prevent a railroad whose proposed terminus was opposite Saint Louis obtaining a charter could also prevent the assent of the State being given to the proposed works. The readiness with which the request when made was granted is unexplained. No document having thrown any light upon it, we are at liberty to attribute it to the generous liberality of the legislature. The grant of this privilege and the successful engineering of the Bloody Island dike settled forever the rivalry between Alton and Saint Louis as to which should be the greater.

In the years following the closure of the Bloody Island channel no matters of general interest arose until by the growth of the city and its trade the extension of wharf facilities was required, and a third stage in the development of the demand for harbor improvement was introduced by the necessities of the traffic across the stream, the number of ferries and railroad transfers requiring that both shores should be permanently accessible at numerous points.

Preliminary to the extension of the wharf a survey was made during the winter of 1860 and 1861, fortunately at a very low stage of water, enabling the remains of old works to be located, and in some instances the map of that survey furnished the only existing evidence of their location. On this survey was based the proposed extension of the wharf northwardly in a straight line from Mound street to above Ferry street, and southwardly in continuation of the convex curve to the then south boundary of the city—Keokuk street. The reports of the city engineer show that this extension of the wharf northwardly in a straight line was very intimately related to the proposition to straighten the river from the chain of rocks down. This project, conceived

by Hassendeubel, was modified by his successor, Homer, to the extent of making the works at the chain extensive enough to compel the main current to pass east of Cabaret Island, which was substituting a moderate bend to the eastward for the upper part of Hassendeubel's straight line, and virtually was a return to the plan of Gratiot and Cram. The current coming out of the chute east of Cabaret Island would have a direction such as to strike upon the front of that part of the proposed straight line below Ferry street, whereas that coming from the natural course of the river, by way of Sawyer Bend, was compelled to cross the proposed line above Ferry street. The line as proposed was not considered to bear any proper relation to a channel coming from Sawyer Bend, as will appear from the following extracts: Hassendeubel, October 12, 1857, states that much had been done to straighten the river by dikes at Brooklyn and Venice. The river coming from Sawyer Bend still tends strongly toward the Illinois shore in that vicinity. A large bar had been formed at North Market street and was increasing, "which in part would be remedied by establishing the wharf as a straight line from Bissell's Ferry to Bates street. I would by no means recommend a convex line, as at some future day the concave bend above Lowell will perhaps be partly abolished." Again, May 12, 1860: "The big bend between Bissell's Ferry Landing and the chain of rocks is now so rapidly increasing that it may within a short period unite with the bed of Gingrass Creek, and the more its curve increases the more the current will be forced against the opposite shore at Venice and Brooklyn, and in doing so must inevitably create a series of sand-bars along our shore between Bissell's Ferry and the shot-tower. That bend should, therefore, be diminished or abolished by an improvement at or near the chain of rocks."

Mr. Homer, October 8, 1860, said: "The tendency of the river is to deflect from the curve which bounds the front of our city, and to prevent this the currents from the north, as far as the chain at least, will have to be guided, and the eastern bank of the river extended westwardly by artificial means, such as occasional dikes, to a curved line parallel with that of the wharf, leaving a width of about 1,700 feet for the bed of the river."

Again, May 13, 1861: "It will be difficult to change the channel to the western shore unless the main body of the river is made to flow from the chain through the slough to the east of Cabaret Island."

May 12, 1862, Homer says: "The northern portions of the harbor can never be considered as entirely safe until the waters are directed from Sawyer Bend to the eastern side of Cabaret Island."

The project thus advocated was adopted. The wharf line was established by ordinance as a straight line from Mound street to the northern city limits, and the construction of the proposed works at the chain were commenced in 1866, and progressed until the death of Mr. Homer in 1868, when they were finally abandoned as useless. The cost of the chain dike is given at \$92,328.81.

Reference to the appendixes shows that the project of diverting a main part of the river to the east of Cabaret Island was substantially proposed by General Gratiot in 1834; repeated by Cram in 1843 and 1844; discussed and favored by Long and Kearney in 1844; revived by Hassendeubel in 1857 to 1860; continued and adopted under the recommendation of Homer. The plan then was not hastily conceived, and though it proved a failure, Mr. Homer is not justly charged with all the responsibility. He carried out the plan of Gratiot, Cram, and Long, with only such modification as to length and location as was to be expected. Kearney seems to have had a better understanding of the effects of dikes and dams, and if his recommendations had been carried out when made, they would doubtless have proved successful, for the project then was much more practicable than when revived by Hassendeubel and Homer. At the later time the river had practically deserted the chute east of Cabaret Island, and a considerable rise above ordinary low stages was required before any water flowed through it. This change in the conditions also acquits the officers who indorsed the plan at first from participating in responsibility for the errors which were made by the city officials.

Engineers then had but a vague conception of the difficulty of compelling a large stream to take a new course as a whole, and scarcely dreamed that there could be any great task in dividing the water and causing an increased proportion to flow where some did already. Even to this day many do not realize that silt or sediment bearing streams present special difficulties in the way of diversion or division of their waters by artificial means, arising from the natural tendency of minor channels in silt-bearing streams to fill or choke up, a tendency due to the slacker current and diminished transporting power of the stream when divided.

The practical construction of the chain-dike was not judiciously carried out, for the work lingered along through two years, whereas success could only be attained by rapid construction, begun after the water had risen enough to flow freely through the slough, and pushed rapidly forward so as to make the contraction of the channel it was desired to reduce, arrive at a maximum if possible before the river reached its maximum discharge. Obviously, whatever progress was made upon the works when

the river was too low to give a current through the slough could result only in the enlargement of the old main channel, and so defeat the purpose of the dike. The attempt to build a dike in full section instead of in horizontal courses of the full length of the proposed work was also injudicious.

Another serious practical error was committed in pushing forward the work of defining the new city front by constructing a longitudinal wall on the straight line which had been adopted properly enough, but the construction of which ought to have been deferred until the proposed change of the current expected from the works at the chain had been secured, for the propriety of that line was based entirely upon the success of the works above. Instead of prudently awaiting the event, there was expended upon the construction of a longitudinal and various cross dikes above Bidle street, between December, 1866, and September, 1868, \$194,840.72. Concerning the utility of the cross-dikes there is no question. Allowing that they cost 45 per cent. of this sum, which is doubtless too great a proportion, the remainder, representing the cost of the longitudinal wall and sundry local revetments, was an investment whose ultimate value depended upon the result of the experiment at the chain. Putting this sum with the cost of the chain-dike and the experiment is debited with about \$200,000, for which little or no return has or will ever be made.

The manifest failure of the chain-dike destroyed, for the time, the confidence of the public in home engineering ability, and after much discussion an ordinance was passed authorizing the employment of a suitable person to make a survey and report a plan for the improvement of the harbor. This survey was placed under the charge of Major William E. Merrill, Corps of Engineers, United States Army, who entered the service of the city for the time and purpose, making the survey and report as an individual, and not as an officer of Engineers. As his survey and report was an elaborate one, valuable in itself, and not readily accessible, the project of improvement is copied in full. (See Appendix P.)

Major Merrill clearly put himself upon record to the effect that in an engineering point of view it would be preferable to abandon the straight line for a curved one, in which case he says: "With ~~such~~ lines thus established in accordance with natural laws, there would be no difficulty in making permanent shore revetments, or in keeping the channel from changing." The reasons he assigns for sacrificing this preferable method are, in brief, first, much money had been spent in establishing the straight line; second, there would be some difficulty in lengthening established sewers; third, it would require time to reclaim the new area to a height useful for building; fourth, claims for indemnity would be made by property-owners whose ground would then be inland instead of river-front property.

The first of these reasons is disposed of by the consideration that when an error is recognized, the sooner it is abandoned the cheaper. As to the sewers, their mouths being choked with sand now, the grade is practically flattened and their course extended as open channels as far as would in any case be necessary. It is even now considered a necessity that the sewers should empty into a swift current, that the *débris* and filth may be swept away, and the time is not far distant when, by the growth of the city, the increased volume and offensiveness of the sewage will render it an intolerable nuisance if permitted to enter the river and pass along the front of the city. In time an intercepting sewer will be a necessity. The construction of a section on this part of the front would merely anticipate and render doubly useful what eventually will be required for the single use of abating a nuisance.

Regarding the reclamation of ground, it is not a question whether land shall be reclaimed, only where it shall be. The river must be narrowed, if not by encroachment from the city side, where the value of the ground will repay to a great extent, if not entirely, the cost of reclamation, then it must be reclaimed on the Illinois side, where it is and must be almost valueless, at least for any period within ordinary forethought.

As to the apprehended claims for damages, when the improvement is carried out claims will arise whichever front be extended. As a matter of municipal policy it would certainly be better for the city to meet and settle such claims with her own citizens and under local laws than to encounter claims probably nearly equal in amount made by citizens of another State, whose claims would be adjusted by the courts of that State or of the United States.

If each of these arguments of Major Merrill be given their full weight (and they all have a basis in money value) and the matter be discussed in its financial aspect alone, it is by no means certain that finally the convex front would not be the cheaper. If we look no further than the single point stated by Major Merrill, the straight line plan "will be an unnatural and therefore an expensive one." This discussion will be resumed later.

The report of Major Merrill was criticised by City Engineer Bischoff (Report No. 1728, October 11, 1879), who said: "The proposed works in Sawyer Bend, unless greatly modified, would not resist the action of the current. A longitudinal dike in the main channel would be extensive, costly, and need repairs for many years." (This criticism

must have been founded in misapprehension of Merrill's meaning, for Merrill's longitudinal dike is along the shore as a footing for a revetment, and not in the main channel.) He continues: "For the improvement of the harbor two plans may be devised: First, indirect, by works in Sawyer Bend, probably spur dikes, rendering results in the harbor uncertain, but probably requiring to be supplemented by two or more dikes from the Illinois shore. The second, or direct plan, is a system of dikes on the Illinois shore, narrowing the river to from 1,600 to 1,800 feet in width. This has partially been done by Bischoff's dike. Not many years hence two cities on this front will require deep water upon both sides of the river; then the complete definition of the water-way will be indispensable. Since 1839 over \$1,000,000 has been spent, four-fifths of which was for harbor (an error); the results are a completed wharf for less than one-fourth the length of the city, and a harbor of which only the central part is available."

The general government having adopted a policy of liberality toward river and harbor improvements, the claims of Saint Louis Harbor were once more presented to Congress, and an order for a survey of the river from Alton to the mouth of the Marmamee was made in the act approved July 11, 1870. The amount of funds and time allotted to this survey was inadequate, and Capt. C. J. Allen, in his report to Lieutenant-Colonel Reynolds, contents himself with a statement of the condition of the river as he found it, and judiciously refrained from recommending any general plan of improvement. This report may be found in Report of Chief of Engineers for 1871, pages 314-327. The succeeding year the survey was continued and special consideration given to the propriety of reopening Cabaret Slough. The report is to be found in Report of Chief of Engineers for 1872, pages 348-354.

A Board of Engineers was convened in 1872, and the proposed improvements were referred to it for consideration and report. That report may be found in Report of Chief of Engineers, 1872, pages 358-367.

It has already been said that the improvement of Saint Louis Harbor passed through two stages previous to 1858; one arising from the necessity of preserving the direct channel of approach to the harbor, the other from the endangered existence of the harbor itself. Under the first the plans looked only to the removal of a sand-bar; under the second to the permanent closure of the chute which threatened to rob Saint Louis of her river entirely.

The first engineer, R. E. Lee, who undertook actual work, doubtless building wiser than he knew, for he does not show in his reports that he foresaw what would be required in the future, proposed works which, if they had been carried out, would not only have served the end he had immediately in view, but also have forestalled the second stage, and indeed the third or present phase of improvements required. His map dated September 30, 1838, shows a projected line leaving the west side of Kerr's Island and stretching diagonally across the head of the east channel to Bloody Island, thence through the island to its foot, whence it extends down stream as a dike. Of this line the lower part was constructed from the middle of Bloody Island to the prolongation of Market street, about 3,400 feet, in 1838. The upper part, from Kerr's Island toward the head of Bloody Island, was built to a length of 3,800 feet in 1839, 1840, and 1841.

Had the line then drawn been adhered to strictly, and the reformation of the Missouri shore been made in reference to it, the trace would have been a better one than now exists, or indeed than is now possible, except by a return to that very line, for it would have insured gradually converging lines reaching from the natural width of the river at Bissell's Point to about the site of the bridge, and continuing downward parallel to and about 1,600 feet from the central Saint Louis wharf.

Not till 1869 does there appear in the records a distinct recognition of the fact that a navigable depth of water was necessary on the Illinois shore, although it cannot be supposed that it had not been realized long before. Attention must have been drawn to the necessity, shortly after the completion of the first railroad with a terminus at East Saint Louis, for equal facilities on either side for the vast bulk of business which must cross the river. The advent of railroad ferrying in 1869 and its growth and importance now, in competition with the bridge, puts the demand for harbor extension and preservation upon a new footing. It is no longer a matter of local interest only, but of real moment to all sections whose commodities cross the Mississippi at Saint Louis or any point near enough to be a competitor for the passage of east and west bound freight. The importance of this transit business will be best seen by the following, taken from the statement of the business of that part of the Mississippi River between the Illinois and Ohio, for 1876, prepared by S. S. Hutchins, and published with the annual report of Col. J. H. Simpson, in the report of the Chief of Engineers, 1877:

	Tons.	Value.
Receipts by river in 1876.....	1, 222, 631	\$33, 000, 716 40
Shipments by river in 1876.....	874, 099	60, 761, 262 84
Total.....	2, 096, 730	98, 761, 979 24
Transfers at Saint Louis across river.....	1, 627, 083	79, 695, 928 00

This last statement is exclusive of the weight of cars or other vehicles, loaded or empty, teams or passengers. It is made from returns of all the ferry and transfer companies, together with tugboats doing jobs and delivering coal, all of which crossed the river. Considering that these figures are for a year when business was greatly depressed, and that for a portion of the year sharp competition existed between the bridge and transfers, it is evident that we have an interest which the public advantage requires to be fostered and preserved.

When the extent of yard room and the other conveniences demanded for the termini of so many important roads as now center at Saint Louis is considered, the importance of allowing that yard room to be obtained by expanding up and down the river and immediately upon its banks, with ready opportunity of transfer from one road to another without the delay and cost of switching and waiting turn to cross the bridge, is readily perceived. Harbor improvements, to afford the room and opportunity for these facilities by reclamation of ground out to limits securing a navigable depth of water from any point in any direction, are as much, perhaps more, a matter of import to the railroad than to the boating interests. Combine with these, tracks and inclines, elevators and warehouses, for the economical handling of bulk grain and package freight, for storage or transfer from river to rail, or *vice versa*, and no justification is needed for the adoption of an extended scheme of harbor improvements and its execution upon a scale commensurate with the value and magnitude of the commerce which will be facilitated thereby. The scheme in extent, probable cost, or difficulty of execution, falls short of the improvement of the Danube at Vienna, already far advanced toward completion.

The complete improvement requires, first, the fixation of the banks above the city so as to control the approach to the harbor and preserve the conditions of entrance invariable; second, the regulation of the width and depth in front of the city by regular permanent lines of definition at high and low stages.

The first requires the revetment of the right bank for the whole length of Sawyer Bend, and possibly of a section of the Illinois shore opposite to and above the Chain of Rocks: also, the closing of Cabaret Slough by a high embankment and the revetment of the head of the island. Besides the works here named it is improbable that any will be required for many years upon that part of the city front above the water works. The concave bank insures the permanent location of the channel close to the Missouri shore, and the west side of Cabaret Island is more likely to receive accretions than to suffer abrasion. Therefore, unless by growth of new interests, or unforeseen expansion of existing, a necessity should arise for deep water on the east side, this part of the river may be considered the approach to the harbor, and, except the works named, may be left to nature. The extent of bank to be revetted in Sawyer Bend is 27,000 feet, of which 1,178 feet is now completed, 3,600 protected by a footwall and spur-dikes, while 1,450 at the lower end and immediately in front of the water-works has the footwall only. This last-mentioned piece of wall was built by the board of water commissioners previous to the commencement of work by the United States in 1872, and compelled the adoption of its direction for the work above, although that direction makes an angle of $21^{\circ} 30'$ with the established wharf-line, which may be considered as terminating at the inlet tower of the water-works.

The trace of the wharf-line starting from the inlet tower and running down stream is—

	Feet.
At water tower, deflection to right, $21^{\circ} 30'$	12,080
At Mound street, deflection to right, $4^{\circ} 4'$	1,525
At Smith street, deflection to right, $3^{\circ} 22'$	845
At Ashley street, deflection to right, $7^{\circ} 43'$	2,365
At Morgan street, deflection to right, $7^{\circ} 00'$	1,353
At Locust street, deflection to right, $6^{\circ} 15'$	1,220
At Market street, deflection to right, $0^{\circ} 35'$	1,175
At Spruce street, deflection to right, $0^{\circ} 24'$	3,410
At Chouteau avenue, deflection to right, $5^{\circ} 45'$	8,025
At Lesperance street, deflection to right, $7^{\circ} 19'$	

If we study this trace on the map we will find it open to criticism on theoretical grounds; but if we visit the ground itself we find a stronger criticism below the water tower in the shape of a deposit covering a section of paved wharf, making the water's edge at a foot stage 70 feet outside of the low-water front-line as established. This deposit now extends along shore to near Bremen avenue, and thence as a bar pointing out into the river as far as North Market street; and a like result in the central part of the harbor, where mud and sand are deposited by every high water on the paved wharf under the lee of the sharp curve from Ashley to Locust street, the deposit falling most heavily from Washington avenue down. The bridge abutments are chargeable with some of this deposit, but not with all, for the principal part of the east abutments do not cause a similar deposit.

The regulated canalized river harbor will begin near the city water-works, and the

upper limit may properly be fixed at the present Bischoff's Dike, which now extends from the Illinois shore to within 1,570 feet of the Saint Louis wharf. Sixty-five hundred feet below this dike is Long Dike, the end of which is 1,880 feet from the wharf line. Continuing a straight line through the ends of these dikes it will strike the revetment of the west side of Bloody Island, very near its upper end, at an angle of 25° with its direction, showing a faulty trace on the east as well as on the Saint Louis side, which should be remedied if practicable. The advocacy of a correction of the trace on both sides above the bridge is not new. The arguments have been set aside as involving too much expense, and that expense and loss vastly increased by persisting in the construction of the faulty plan; but the force of the argument is unimpaired, and the natural law which demands the change will never be repealed.

As has already been noticed, Major Merrill clearly saw the true solution of the difficulty, and ought to have thrown aside the consideration of expediency which induced him to countenance an adherence to the old line, for at the particular juncture when he made his survey the folly of the old plan was recognized in the community if not in the city engineer's department, and the whole plan could have been overthrown and abandoned as readily as the leading part was if a respectable professional opinion had furnished the reasons why the line, which was but an adjunct or consequence of the original plan, must necessarily fall with the abandonment of the leading feature of the scheme, that the channel was to enter the harbor from the east side of Cabaret Island.

The angle at the water tower at that time was not defined, but that the existence of difficulty in the alignment was known is shown by the criticism of Merrill's report by Bischoff already cited, where he says: "The longitudinal dike in the main channel would be extensive and costly, and would require repairs for many years." True, Merrill did not recommend any longitudinal dike in the main channel, but Bischoff, knowing of the angle between the wharf-line and the direction of the natural bank, naturally took it for granted that to prolong the line either straight or as a curve, would necessarily throw the dike Merrill recommended out into the channel, although Merrill's language very conclusively shows the "low longitudinal dike" to be at the foot of the natural bank.

His argument is as to the necessity of not allowing Sawyer Bend to be deepened and so render the angle at which the river enters the harbor more unfavorable. But he does not suggest that the bend be straightened unless it be by forced construction of the following: "There are two ways of protecting this shore, by a series of dikes or by revetment. We may build a few long dikes or many short ones." Long dikes would have implied straightening the bend, but he prefers revetments of the actual shore. Merrill accepted the direction of the current from Sawyer Bend as a fixed unfavorable condition which could not be bettered, but might, and, unless remedied, would become worse; and he proposed by enforced contraction to overcome the difficulty and "force the river to come to the wharf which the city has established," which he acknowledges "will be unnatural and therefore expensive."

When the Board of United States Engineers met in 1872 Merrill's plans were practically indorsed; but as there is no mention of the question of alignment, it is probable that it was not definitely brought to their attention. The map which was before the board for their information did not show the prolongation of the straight city front to its real termination at the inlet tower, but showed it as terminating about 800 feet below its then visible end. The tower itself was not finished, and its location was not on the map; nor was the cross dike shown which connected the tower with the shore, nearly 150 feet distant (possibly the dike was not built at the time the survey was made); neither did the map show, nor did any person connected with the local office know, that after the survey was made a line of rip-rap wall had been constructed, extending from the inlet tower up stream in a straight line to Grand avenue, a distance of 1,450 feet. These unknown and unrepresented conditions not being before the board, it was naturally supposed that the distance from Grand avenue to Ferry street, 2,200 feet, was ample length for a curve to join the direction of the river bank above Grand avenue with that of the wharf line below Ferry street. Moreover, the then bank above Grand avenue showed a direction making a much smaller angle with the line of wharf than that made by the hidden rip-rap wall and the wharf.

The board not being familiar with the locality and not informed upon essential facts not visible at the then stage of water, are blameless. Naturally Bissell's Point was not a sharp one, but its prominence has continually increased with the deepening of Sawyer Bend. The location of the inlet tower about 150 feet out in the river artificially transformed the curve into a salient angle. The close proximity of the engine-house and settling-reservoirs forbids the thought of easing the angle by removing the point.

When, Congress having indorsed the recommendations of the board by appropriating money toward the execution of their plans, it became necessary to locate the proposed works, the surveys developed the facts recited above (and as whatever was done would

in no small degree influence the future), Capt. C. J. Allen addressed the officer in charge, Lieut. Col. W. F. Reynolds, a letter, as follows :

"SAINT LOUIS, MO., August 31, 1872.

"COLONEL: I understand that there is some probability of the line of the Saint Louis wharf, northern, being changed from its present shape so as to take in a portion of the extensive sand-bar that now obstructs the landing along that wharf. Such change must, it seems to me, greatly modify our proposed work in the Venice Bend.

"When the Board of Engineers met here last winter it seemed to be a settled matter that the wharf-line as now established, and as shown upon our map of 1870, was to be maintained; consequently, in order to bring the low-water channel to the proper width, certain extensions and raisings of dikes in the Venice Bend were found necessary. If, however, the city proposes to change the shape of the wharf, the extension of Long Diike will hardly be necessary (at any rate not to the distance now contemplated), and Bischoff's Diike will probably require shortening, and an additional dike required between the Long Diike and the head of Bloody Island.

"I don't think that any member of the board doubted that better results would obtain if the northern wharf-line were changed so as to make it convex to the river and form a proper tangent curve to the curve of Sawyer Bend, but at that time there seemed to be no probability of the city changing the line that had been established at some expense.

"The alterations in the plan of the proposed work in the Venice Bend would not conflict with the principle adopted by the board for the improvement of this particular portion of the river, viz: contracting the width of water-way; but would involve changes in location and dimensions of work.

"As the work now to be commenced will most probably be the inauguration of a proper and comprehensive system of works (not necessarily carried out by the government, however) to remedy the evils in this harbor, I think it of the utmost importance that whatever is done now should not be subject to radical change in the future, and that it would be better to defer the work (if necessary to do so) for an indefinite time, rather than construct any works that might have to be eventually removed in order to meet changes in the wharf-line.

"As the work has already been advertised, and our operations must commence very soon, I earnestly invite your attention to this matter.

"I am, Colonel, very respectfully, your obedient servant,

CHAS. J. ALLEN,

"Captain Engineers and Brevet Major United States Army."

"Lieut. Col. W. F. REYNOLDS,

"Corps of Engineers, United States Army."

Colonel Reynolds had previously written to the city engineer, J. B. Moulton, the following note:

"ENGINEER OFFICE, UNITED STATES ARMY,

"Saint Louis, August 29, 1872.

"DEAR SIR: Is there any probability, present or future, that the line of Saint Louis wharf, northern, will be changed so as to include any of the sand-bar now in front of it—that is, changing it from a straight line into a curved one?

"If any such change is likely to be made we should know it now, as it would materially affect the location of the works to be commenced in the Venice Bend.

"Very respectfully, your obedient servant,

"W. F. REYNOLDS,

"Lieutenant Colonel of Engineers, U. S. A.

"Colonel J. B. MOULTON,

"City Engineer, Saint Louis."

And subsequently, to Brig. Gen. A. A. Humphreys, Chief of Engineers:

"ENGINEER OFFICE, UNITED STATES ARMY,

"Saint Louis, Mo., September 17, 1872.

"GENERAL: Our examinations in the vicinity of the water-works for the purpose of projecting the improvements in this harbor have developed the fact that since our last surveys the authorities controlling the water-works have been making quite extensive 'improvements,' which indicate that the city authorities will be compelled to change the wharf line in the northern part of the city.

"A heavy stone revetment has been placed in front of the water-works property extending for a distance of about 1,450 feet above the inlet tower. This revetment has been placed in a straight line, which prolonged makes an angle of over 20° with the straight line established by the city as the wharf line below the inlet tower. The two parties seem to have been working independently; the result is the angle as stated. The accompanying sketch shows the condition of affairs. The straight line

of the city wharf produced, it will be seen, strikes to the westward of Cabaret Slough showing, I think, that it was established when it was thought the water would be thrown into the channel by Long Chain dike. This expectation having failed, the suitability of the line as established fails with it, and I cannot but believe that the time will come when the city will be compelled to change that line somewhat, as indicated by a red line on the sketch.

"Some time since, in conversation with the city engineer, he intimated to me that such would be the case, whereupon, on the 29th of August, I addressed him an official note asking as to the probabilities of such change being made. As yet I have received no answer to my question.

"As the matter presents itself to my mind, we have two parties, the city and the water-works, working independently, and between them a serious engineering blunder has been committed, and now they are waiting for the general government to step in and perpetuate the error.

"I therefore ask authority to change the proposed plan of operations, and instead of extending the long dike, to build another dike between it and what was the head of Bloody Island. It is true the Board of Engineers proposed to leave the erection of this dike until the effect of the extension of the long dike was known, but I cannot doubt that it would even in that case be found necessary. Its effect will probably be quite as great to remove the lower and most troublesome part of the bar above the elevator as the extension of the long dike. Its erection now instead of the extension of the long dike leaves the question of rectifying the mistakes already made an open question.

"Very respectfully, your obedient servant,

"W. F. RAYNOLDS,

"Lieutenant-Colonel, Corps of Engineers.

"Brig. Gen. A. A. HUMPHREYS,

"Chief of Engineers, U. S. A."

City Engineer Moulton replied as follows, and a copy of his letter was sent to the Chief of Engineers the same date:

"SAINT LOUIS, MO., September 19, 1872.

"I have received your letters of dates August 29 and September 9, which would have been answered sooner if I had been in the city.

"In the matter of changes in the present wharf line as established by law and city ordinances, extending along the river in front of the city, my opinion is that no changes will be made where it is improved, and the probabilities—which may, I think, be regarded as certainties—are that no changes will be made where the longitudinal dikes are not made. My reasons are that the city has at great expense made the longitudinal dike, paved and macadamized the slopes on the wharf, and built the sewers to low-water mark, so that in extending them further into the river the grade of fall could not be preserved, and they could not wash out. There are other reasons which would make the cost of change very great.

"Besides this, if the stone dikes on the east side of the river be extended westwardly, so as to contract the river to about 1,500 to 1,600 feet, and raised higher than they are at present, particularly the one known as 'Bischoff's dike' and 'Long dike,' we are of the opinion that the water in our harbor from Bissell's Point to the Coal dike, and as far below as the deep channel will affect it, will be deep and permanent.

"I am authorized to say that the chairman of the city council committee on harbor fully indorses this opinion, and is of the belief that all the members of the committee and of the city council will take the same view of the question.

"Respectfully,

"J. B. MOULTON,

"City Engineer.

"GENERAL RAYNOLDS, U. S. A."

The Chief of Engineers disapproved of General Reynolds's recommendation:

"OFFICE OF THE CHIEF OF ENGINEERS,

"Washington, D. C., September 28, 1872.

"SIR: Your letter of the 17th instant, recommending a change in the plan of operations proposed by the Board of Engineers for the improvement of the Mississippi River between the mouth of the Missouri and the Meramec, has been received. Your letter of the 19th is also received.

"Upon consideration I am unable to concur in your recommendation, and think that the plan of the Board of Engineers should be carried out; that is, Long dike should be extended.

"Very respectfully, your obedient servant,

"A. A. HUMPHREYS,

"Brigadier-General and Chief of Engineers.

"Lieut. Col. W. F. RAYNOLDS,

"Corps of Engineers, U. S. A."

With the letter of Colonel Reynolds to the Chief of Engineers is a sketch showing the proper outline extending from the tower down to the elevator at Biddle street. This line and a corresponding trace on the Illinois shore will be reproduced, so far as the limits of the sheet will allow, on the map accompanying the report of Col. J. H. Simpson, Corps of Engineers, U. S. A., on damages, &c., to riparian owners of land at or in front of Venice, Ill.

This line has a versed sine at Dock street of 625 feet. Unquestionably this line was, and is still, the one which ought to be adopted, because it is the only one which allows the possibility even of a practical landing along the entire front. Should Merrill's plan (or that of the board) be carried out, the angle at the tower will cause the current to leave the Missouri shore and naturally make an eddy. The deflected current, a short distance below, encounters the contraction at Bischoff's dike. If this dike be raised to any considerable height, its outer end must contend for existence against all the mighty forces of the river, which nothing but a mass of material founded below scour sixty or more feet below low water, could stand. It must be remembered that this discussion is not limited to a view of things as they now are, but is an effort to foresee the final results of completed works. Therefore, in speaking of the difficulties to be met, a high dike, above ordinary high water at least, occupying approximately the position of Bischoff's dike, is meant. This dike will be the head of a longitudinal dike or revetment of the reclaimed land, extending from this head dike to the head of Bloody Island, and this longitudinal dike will also be raised to a height above ordinary high water. In other words, the work of regulating the river is supposed to be complete.

The motion of water in rivers is due to a single cause—gravity. The direction of that motion is determined by other and often by many causes. Gravity acting alone can produce motion, but in a straight line, and that vertical. Combine with gravity a projective force, acting in any direction out of the vertical, and the path is a curve, and the character of the curve will vary with every new or additional force brought into action. Place an obstacle in the vertical path and it may be made approximately parallel to the earth's surface, as is the case in running streams. Gravity is the sole cause of motion: all other forces obstruct the flow and divert the path. Taking the case of a river of considerable size, and, to simplify the matter, supposing the velocity to remain uniform for the length of section under consideration, so long as the direction in which gravity is applied coincides with that of the previous motion of the water, the current will continue in a straight line, unless turned aside by the accidents of the bed.

Assuming the absence of disturbing causes, and that gravity and momentum are the only elements of the motion, it is plain that the direction of the action of gravity is determined by the slope, and that direction is the line of greatest declivity or slope. We will now assume curvilinear parallel banks to our stream, for a certain section of definite length, and consider that the terminating sections are radical to the curvature of the banks, also that the surface of the water is level at the sections. Now, if the width of the stream be divided into any number of equal parts, the lines of division will be parallel lines, joining points of equal or common elevation; that is, each line has an equal descent to any other line, but not an equal slope, for the paths differ in length. These lines certainly represent the direction in which gravity acts upon the particles of water found at any time upon the particular path which may be under consideration. Comparing two particles at the extremes of the width, the particle at the concave bank has its line of greatest declivity along that bank, and the particle at the convex bank has its line of greatest declivity along the convex bank; but the latter, having the shorter path before it, and therefore the greater slope, is more energetically acted on by gravity than its fellow on the concave side, therefore ought to move more rapidly, and by viscosity of the fluid draw in some small degree that fellow after itself. In this view the strongest current and greatest body of water would be found on the convex side. Notoriously this is not true; but, on the contrary, if the bend be long enough, the swifter current and greater volume is almost invariably found on the concave side. Let us now add to the suppositions already made the condition that the particles of water cross the ideal upper section with a certain velocity and consequently momentum. The direction of previous motion is tangent to the curve, which has before been considered the line of action of gravity. Momentum, then, is a tangential force and gravity circumferential. The resultant path of the particle must be between the curve of gravity and its tangent at the beginning of the curve. Assuming constancy of motion for the individual particles, but a variation of velocity from a minimum at the bank to a maximum in the mid-stream, the theoretic trace of particles may be determined and a series of such traces, counting from the convex shore, will be found divergent, until we arrive at the path of the particle having the greatest velocity; beyond this the paths will be converging. Calling these traces stream lines, and assuming that the quantity of water contained between two consecutive stream lines remains constant, it is evident that diverging stream lines imply diminishing depth, and converging increasing depth, and we have

a theory accounting for the transfer of the deeper and swifter current to the concave shore, and a slacker current and conditions favoring deposit along the convex side.

Thus far none of the water has come in positive contact with the concave bank and has not been deflected by it, and we arrive at the conclusion that there may be curves or bends around which a stream may pass without loss of motion by impact upon banks and without endangering in the least the stability of the banks; also that the convex shore has no insignificant influence upon the position and depth of the "thalweg."

In streams of approximately constant volume and velocity, traversing a bed of finely divided alluvion, the adjustment of the degree of curvature of bends to the slope and velocity ought to be closer and the regimen more stable than in streams subject to great and quick changes of volume and velocity and traversing coarse soils, or such as vary greatly in their composition. Take the Lower Mississippi, for instance, below its last great tributary, the Red River. The volume and velocity vary, it is true, but the changes are gradual and occupy months. The bed is composed of finely divided material, which readily permits the river to adjust the elements of depth and width at will. The stability of the banks increases as we go down stream, although the increasing fineness and homogeneous character of the soil would certainly increase the liability to erosion, did not these very characteristics favor a smooth, regular outline of bank, along which the water may glide without coming in contact or impinging upon any obstruction or irregularity, solely under the influence of gravity and inertia.

Under other conditions, natural or artificial, the adjustment of the trace of banks to slope is very imperfect, and in all such cases no small part of the energy of the stream is expended in work upon the bank, building up and destroying.

With this exposition of the importance of regular and carefully adjusted lines, we will return to the consideration of the current coming out of Sawyer Bend. The trace above the inlet tower being straight for nearly 5,000 feet, the direction of flow when passing the tower, if prolonged 4,500 feet, will strike a line parallel to the present wharf-line, and 1,560 feet from it, as proposed by Merrill. The line of deepest water, which in the bend above has been about 150 feet from the bank, in the natural stream makes the crossing and keeps above this line. We may, therefore, suppose that when the line laid down by Merrill is completed, the line of deepest water will make the crossing and arrive at a close approach to the new east bank before crossing the line of the west bank produced. Therefore, the force of a great part of the river's volume must be met and the flow reflected upon the 2,300 feet of new bank above that line. The reflection of the current, involving a change in the direction of the flow of many degrees, must have an adequate cause. That cause we have in the impact of the current upon the bank, for the arrested motion is converted into height due to velocity or head, and, under the head thus produced, the water flows away in a new direction with a new velocity. The new direction is the nearest approximation to the line of quickest descent possible, and therefore tends to parallelism with the bank.

The contest of forces attending the arrest of motion is hostile to the stability of the bank, and if the bottom be mobile, the depth of scour is without known limit. Experience confirms theory here. A contraction of the river is made at the head of the Saint Louis and Illinois Railroad Company's dike much less abrupt than the proposed one under consideration. The depth in June, 1875, off the end of the dike was said to be over 70 feet. Below Saint Louis, at Horsetail Bar, the outer end of dike No. 3, after having been out of water two years, at least 15 feet at low-water, was undermined by a change of channel in the winter of 1875-'76; was restored in the fall of 1876; sunk again during the winter of 1876-'77; restored in the early spring; was, after the subsidence of the annual summer rise, found to have 24 to 28 feet of water on it at a 15-foot stage. The depth in the fall of 1877, by the nearest sounding that could be made on account of the violence of the current, was 63 feet, about 100 feet below the end of the dike, proving that the foundations of the dike were at least 60 feet below low-water. In this case the conditions were not dissimilar to those of the case under consideration (for the dike was resisting and deflecting the whole force of the river at the stage of 9 feet above low-water), except that the width available for the river was over 3,000 feet, and, in the case under review, is supposed to be 1,560. It is, therefore, no more than reasonable to suppose that the water along the upper part of the new east front will be at least 60 feet deep, and the foundation of the works must be equally deep, which certainly must be very expensive.

Proceeding upon this established probability of a depth of 60 feet on the east side at low-water, what will be the prospect for navigable water on the Saint Louis side? Supposing the form of cross-section to be a triangle (and it must approximate one, for the conditions forbid the possibility of a middle bar), the area at a low-water stage would be, approximately, $1,560 \times \frac{60}{2} = 46,800$ square feet; at a 7-foot stage, approximately $1,560 \times \frac{67}{2} = 52,260$; at a 12-foot stage, approximately, $1,560 \times \frac{72}{2} = 56,160$.

The discharge of the river at the stages being, approximately, 36,500, 72,000, and 148,000 cubic feet per second, the mean velocities cannot exceed 0.8, 1.4, and 2.6 feet

per second. As these velocities all fall below those found in the Mississippi, the section is not a possible one, and the width must be reduced. In fact, the river in many places passes through a cross-section of 15,000 square feet at low-water. The depth assumed in such a cross-section will not allow a width of over 500 feet— $15,000 \times \frac{2}{3} = 500$. In fact, the river at Elwood street, Carondelet, with a channel depth of 45 feet, in 1873 was less than 1,100 feet wide, and at the coal-dump, South Saint Louis, after contraction by the dump to 1,700 feet, the river did not furnish sufficient depth of water at the dump for loaded boats, and the dump was extended 450 feet; still, complaint is made that the water is insufficient. By theory and practical example, then, we have demonstrated that when the conditions are such as to favor very deep water along one bank no practicable amount of contraction is able to secure a depth sufficient for any useful purpose on the opposite.

That contraction of less than 1,560 feet is dangerous will readily be seen. Supposing slopes of banks or levees to be 5 to 1, at a 22-foot stage the width on surface will be 1,700 feet. If the depths be uniform, the mean velocity to pass the then discharge of 369,000 cubic feet per second must be about 7 feet per second, which is very near the safe limit, and this is but an ordinary summer stage. A flood would double this discharge at least. Unfortunately, no actual observations of the flood-discharge of this part of the river have been made, and recourse must be had to approximations. On August 4, 1866, the water falling and reading 12.7' above low-water, the discharge was 211,073 cubic feet per second. On October 24, 1866, at the turn of a quick rise, the gauge reading 19.67', the discharge was 384,075 cubic feet. Taking the differences of the corresponding terms, and we have a difference of 173,002 cubic feet in discharge, with a difference of 6.97' in stage. This difference in discharge does not bear any known ratio to that of stage, for the observations were made under very unlike conditions. The smaller discharge being observed when the river was falling, is considerably smaller than it would have been at a like stage when the river was rising. The larger discharge was taken at the very top of a quick rise, and probably represents nearly the maximum discharge for the stage 19.67'. But we will offset this consideration by assuming the variation of area to be directly as the rise of the surface, and also that the velocity remains the same at a high stage as at a low. A rise to the level of the city directrix, 33.81' above low water, will give an increased discharge $\frac{173,002}{6.97} \times (33.81 - 19.67) = 349,000$; add discharge to 19.67 given above, 384,000; gives a discharge of 733,000 cubic feet per second.

Allowing 1,560' for the width at low-water, and slope of banks 5 horizontal to 1 perpendicular, and assuming the low-water area at 15,000 square feet, the increase of area for a rise of 33.81 will be $1,730 \times 33.81 = 58,474$, making a total area of water-way 73,474 square feet.

Taking the actual low-water discharge at 36,500 cubic feet, and assuming a cross-section of 15,000 square feet, or, say, a mean depth of 10 feet, we must have a low-water mean velocity of 2.45 feet per second. On the acknowledged principle that velocities vary nearly as the square roots of the depths, the ratio of high to low water velocity would be as $\sqrt{33.81} : \sqrt{10}$, or as 1.84 to 1, nearly; whence the main high-water velocity would be $2.45 \times 1.84 = 4.51$ feet per second, nearly, which, multiplied into the area given above, gives $73,474 \times 4.51 = 331,368$ cubic feet as the discharge, which could pass the proposed cross-section without changing the natural slope. The estimated discharge, 733,000 cubic feet, would require, to pass the section, a mean velocity of very near 10 feet per second, which is as high a velocity as we can prudently expect revetments to endure, and they must be in perfect order or they will fail, and results follow beyond all human foresight. To obtain this increase of mean velocity there must be an increase of head, or piling up of the waters above the city—in other words, the works will act as a dam, showing that the contraction is too great for safety. A rise such as has been considered would not be a flood, but would be an unusually high water. The floods of 1844, 1851, and 1858 would exceed it by 7.58, 2.80, and 3.28 feet, respectively.

It has now been shown by safe approximations, first, that the proposed low-water width of 1,560 feet does not promise a navigable depth of water along the upper part of the wharf, say above North Market street; second, with that width at low-water and banks rising above high-water, with the usual slope given a paved wharf, the contraction in time of flood exceeds a safe limit; third, the construction of the confining works has been shown to be very expensive.

These reasons demand and justify a change of plan, or, at least, important modification of the conditions which were imposed. First modification demanded is that the reclamation to high-water mark cannot extend to the top of an ordinary slope, starting at low-water mark, if the low-water width be 1,560 feet. In order to reduce the high-water mean velocity to about 7 feet per second, if the front line is to mark the width at stages below +7 feet, it will be necessary to retract the high-water limit about 1,000 feet, leaving a flat fore shore of that width. Such a fore shore would cut off all access to this part of the east front at stages from 7 to 12 feet, unless the front line be broken by openings to provide channels by which boats could pass to the main bank when they

could not pass over the front wall. As such a fore shore would be a place of holes and bars, no certain provision could be made for such access, unless by leaving so many and large openings that the front wall is virtually dispensed with and a series of low dikes or pier-heads substituted. Further consideration of the matter will be postponed until other elements are introduced which affect the question of what the trace above Bloody Island should be.

In front of Bloody Island both sides are already established, and it would be useless to suggest a change. A discussion of the probability of a flood passing this section without damage may be found in Capt. J. C. Allen's report to Col. J. H. Simpson, June 30, 1873. (Page 474, report of Chief of Engineers, 1873.) Also Colonel Long on the same general subject. (See Appendix M.) The front on Bloody Island is approximately that designed by Lee in 1838. From the foot of Bloody Island to the Illinois and Saint Louis Railroad dike the ground is low, but extends well out toward the prolongation of the island front. Below the railroad dike the extent of accretion is great, but is now rather diminishing than increasing. Another firm dike is greatly needed in the vicinity of the Cahokia Ferry road, particularly the part of such dike necessary to cross the slough close along the main shore. At Arsenal Island the work already done will be of no practical use until the proposed dam is completed, when the accretions above the head of the island may be expected to progress rapidly. A suggestion that this dam be made a high one, and the works in the vicinity be carried on so as to preserve the chute below the dam from being filled up, was made in the annual report of Col. J. H. Simpson in 1877. It is there suggested that the pool below the dam may be preserved and made available for a winter harbor, and argument made showing the necessity for such harbor. (Report of Chief of Engineers, part I, 1877, page 505.)

The preservation of the pool for such purpose would simply require the works which are contemplated in the plans of improvement to be carried to completion immediately, and as rapidly as possible after the dam is commenced, instead of leaving them for years unfinished, as would be the most efficient and economical mode of reclaiming the area as dry ground. The suggestions of that report are still deemed worthy of consideration, as meeting one of the recognized wants of the commerce of the Mississippi, which will become more imperative as the improvements above and below progress. Moreover, the opportunity now presented, if lost, is lost forever. A similar opportunity was missed when Bloody Island Chute was closed; and what might have been a great local and public advantage is now but a nuisance, which cannot be abated at any reasonable cost. A rapid formation and prolongation of Bloody Island would have enabled the pool to be kept in communication with the river at comparatively small annual expense.

The first work undertaken for the improvement of the harbor of Saint Louis was a longitudinal dike extending down stream from the foot of Bloody Island. This dike was first suggested by General Gratiot, in report dated April 16, 1834. (See Appendix A.) No immediate action was taken upon General Gratiot's recommendation until it was re-enforced by a memorial in 1836, when an appropriation of \$15,000 was made "for the erection of a pier to give direction to the current of the Mississippi River near Saint Louis." As General Gratiot's plan presented two alternates, and the pier at the foot of the island was admitted to be an adjunct which might be needed to supplement both alternates, it was but a natural modification of the plan that the construction of the adjunct was advanced to precede rather than follow the execution of the other parts of the project, particularly because the pier, from its close proximity and direct relation to the evil complained of, would afford promise of immediate results even with an appropriation insufficient to complete it as designed. Before work was begun an additional appropriation of \$35,000 was made. The work was placed under the charge of Lieutenant and later Captain R. E. Lee, of the Corps of Engineers, whose reports, so far as relate to engineering questions, are given as Appendixes B, C, D, and E.

The actual length of pier constructed is nowhere stated, either in report or upon maps. Captain Cram, February 3, 1844, said: "It appears that in 1839, 1840, and 1841, an extent of about 925 feet of the dike recommended by Captain Lee was constructed." Cram's map shows remains of the dike of the given length. From Kayser's statements we conclude the work must have been about 3,400 feet in length. (See Appendix M.)

The upper end was undermined. In March, 1840, it was reported that parts of the dike near the middle and upper end had caved in and sunk. This part appears to have been built on a dry bar. (See Appendix E.) This settlement seems to have shaken confidence in such works to some extent, and probably led to the substitution of stone dikes, for the more elaborate works of Captain Lee, when work was resumed. No attempt was made to repair the upper end of the longitudinal dike, but cross-dikes were built, from time to time, to protect the west face of the island. Four such spurs were built in 1840; the upper opposite Cherry street, the lower opposite Locust. The main dike below Locust, notwithstanding it had been founded in deep water, was

breached, and a current developed itself which scoured the sand on each side of the dike to great depth.

The foot of the island had probably been extended down stream, as in 1841 a cross-dike was built on the prolongation of the center line of Pine street to connect the dike to the foot of the island; this dike was 150 feet in length east of the dike, and 80 feet long west of dike, forming a spur. In 1842 other cross-dikes were built for the protection of the island, making 7 in all.

The cross-dam opposite Pine street and the spurs above had the desired effect until the flood of 1844, when the ends of the spurs not having been carried high enough, and the shore between the spurs being left unprotected, the lower dikes were cut off, and a channel formed behind them.

Kayser in a report dated July 5, 1847, says: "The city last year decided to close the channel in the rear of the dikes, by continuing the cross-dam before built opposite Pine street to the present shore of Bloody Island, and if necessary to continue it to the main Illinois shore, with the view that it would at least aid in closing the east channel." This extension was made in 1847, and one of the upper dikes was also extended to the island to relieve the pressure upon the dike or cross-dam opposite Pine street.

The reliance upon spur dikes for shore protection was given up, and resort had to continuous revetment, the plan being to construct short cross-dikes, or jetties, projecting from the top of the bank of the island to the contemplated west line of the island, and to slope the bank between these jetties and cover the same with stone. Later, this plan was modified to a simple revetment of a regular slope.

The first suggestion of a dam to close the Bloody Island chute is credited by W. C. Anderson in a communication to the Missouri Republican, December 13, 1847, to Dr. John L. St. John, who was said to have estimated the cost at \$25,000. Captain L. M. Shreve practically recommended a dam in 1834, at the head of the island. (See Appendix A.) Lieutenant Lee followed Shreve in his report of 1837 (see Appendix B), and afterward abandoned the dam for an oblique dike from Kerr's Island, which was begun in 1839.

Anderson, in his letter mentioned above, says that owing to the effect of the oblique dike built by Lee at Venice, the water in the chute had shoaled from thirty feet to three in 1847.

The proposition to close the chute was much discussed in 1846-'47. All Saint Louis opinions agreed that the chute should be closed, but there was much difference of opinion as to the location of the dam. From the very outset it was proposed to make the dike the preliminary step to a roadway, as has already been noticed.

After the compromise of this dispute, by authorizing the construction of two dikes, the continuation of the old cross-dam, opposite Pine street, toward the main Illinois shore, was commenced and pushed in the face of the opposition of the citizens of Illinois, until a section of the main Illinois shore was revetted, and the dam carried across the channel to or above the elevation of low water, with the exception of about 200 feet, which was two or three feet lower. The dam was built wholly of riprap thrown into the river on the line of the dam.

When the legal obstacles were removed, one of the conditions was that the dam should be completed and made available as a roadway. Discussing the plan, Kayser said (see Appendix L) the dam must be raised very gradually, and a period of two or three years allowed for its construction. As the purpose was to reclaim the bed of the chute, this plan of Kayser to build the dam slowly was well calculated to allow the chute to be filled with sediment.

Curtis said October 10, 1850 (see Appendix O), the dam was then about 10 feet above the river, and entirely across the channel. It was proposed to widen this dam with earth, and use the stone to protect the embankment. The top of the embankment was to be 3 feet above the general level of the American bottom, it being properly argued that the embankment would safely be submerged, provided the fall was reduced to a trifle, by the free flow of the water over the bottoms. During the winter of 1850 and 1851, 66,398 cubic yards of earth were put in the embankment. The base of the embankment spread some 100 feet beyond the intended prism, but the dam was a success notwithstanding many had doubted the possibility of making an earth embankment.

On May 12, 1851, Curtis reported the roadway across the chute completed, at a cost of less than \$19,000 (the estimate was \$25,565), wide enough for two teams to pass. It was a sand embankment with a heavy revetment on the *lower side*. He added: "When the river rises care and repairs will be needed. The dike is as high as the directrix, but if overflowed would be destroyed; but such a flood has occurred but once in a century." The confidence expressed in the rare occurrence of floods was quickly shaken, for, on July 22, Curtis was under the necessity of reporting that a breach had been made around the east end of the dike, saying that the flood came at an unfortunate time; but the result did not show that the plans were defective, the loss being due to the incomplete condition of the work.

The dike itself did not give way, but the current washed around the east end. The location was unfortunate, as the east end of the dam was but a short distance from Cahokia Creek, which then ran parallel to the river, and not more than 200 feet from it at the side of the dam. The breach in October was 450 feet wide; and though too deep for piling, it was thought the breach could be more cheaply repaired than another dike could be built. Later, December 11, the breach had widened to 600 feet, and much of the earth embankment carried away. It was therefore proposed to construct a new dike, 3,000 feet above, where a sand-bar occupied most of the slough, the water being only 100 feet wide and 6 feet deep. A service embankment was made at this point during the winter of 1851-'52; but as the city council insisted upon a lower location for the permanent dike, that it might be opposite the center of the city, this service road was not raised to any considerable height.

The loss by the flood did not shake the confidence of the engineer in the plan, which was the same as for canals, levees, and reservoirs elsewhere—revetted earth-work. The new embankment, located by the council, was begun under the protection of the service roadway, which acted as a coffer until a rise in the river, after which the new work had to contend with currents, but was completed without further serious mishap at a cost of about \$130,000. The dike was virtually completed in 1854, but was not turned over to the possession and care of the Saint Clair County authorities. Receiving little attention, the condition of the roadway became a matter of complaint in 1858. To obviate controversy the city repaired the dike and formally transferred it to the care of the county in that year, and its history as a harbor-work ended.

In the first project presented for the improvement of Saint Louis Harbor, the leading feature was to throw the water to the west of Bloody Island by means of a wing-dam (see Appendix A), but a contingency was foreseen in the probability of opposition on the part of the people of Illinois that might prevent the adoption of the plan. Lieutenant Lee, in his report of 1837 (see Appendix B), speaks of essentially the same plan, but places the upper end of the oblique dike above the mouth of the slough. His map shows an alternate plan of a dam directly across at the head of the island, and he estimated the latter in detail. In 1838 (see Appendix C), he withdrew his preference for the direct, and recommended the oblique, dam. The dike as last proposed was begun in 1839, although a map bearing the name of Henry Kayser is authority for the statement that 1,300 feet was built in 1838; but Lee's report of October, 1839, is conclusive that the work was begun August 12, 1839. (See Appendix D.)

Very soon after the commencement of the dike, opposition developed in the form of an injunction, which caused the suspension of the work August 27. That all the residents in the vicinity did not join in the hostile proceedings, though probably all claimed to be injured by the proposed works, we learn from the following full abstract of a communication from the citizens of Six Mile Prairie to the mayor of Saint Louis:

"Whereas the work commencing on Kerr's Island, and thence running downwards, has become a matter of consequence to us, from the fact that it has stopped our ferry-boats and suspended all communication by Kerr's Ferry, and with Saint Louis, except by way of the lower ferry, an additional distance of two or three miles of bad road, which evil will be made perpetual so soon as the work shall be carried across one small channel, we * * * acknowledge a mutual interest between Saint Louis and ourselves, and have not thrown a straw in the way of the works, while other people of our county (Madison, Illinois), and from Saint Clair County, have done their utmost to stop the work. Why did not we join the posse under our sheriff when he came to execute a lawful process? Because our welfare depends on the growth of Saint Louis. The city needed the current on that side of the river, and we could spare it. We were told and believed that all our ferry facilities could be restored by the erection of a dike from the work to our main shore, which we understood from time to time was to be begun, until the season closed and nothing was done. In this deplorable condition of our ferry privileges we press the consideration of our rights upon the city authorities, and request that the said dike be begun and built as soon as possible, which will be received as ample assurance of its completion, and of the worthiness of the city authorities of the confidence which we repose in them.

"S. SQUIRE,
"THOMAS L. LOFTON,
"WILLIAM GILLHAM,

"Committee.

"December 2, 1839."

The injunction of August must have been dissolved and work resumed by the city in October; during this second interval the 1,550 feet built by Kayser in 1839 must have been constructed. Two days after the presentation of the communication the city council ordered work to be discontinued, and the boats, tools, &c., to be returned to the United States officer from whom they had been borrowed. A joint resolution being before the council for the construction of the dike or causeway asked for in the memorial, a select committee reported that they were of the opinion "that as the works

for the improvement of the harbor have been commenced by the General Government on its own plans, and prosecuted by its own officers in accordance therewith, and will, it may be reasonably assumed, be carried out at the earliest proper period to successful completion, and as your committee have not the means of judging how far the construction of the causeway in question might be considered as interfering with the general design and intended operation of the works, it is thought to be advisable, therefore, that the city should leave the whole subject, and all its details, in the hands of the United States."

It is evident that the question of liability for damages was looming up, and that the committee, in their anxiety to shield the city from responsibility, were willing to convey the impression that the works had been commenced by the United States, although this statement was not strictly correct.

The United States at that time had done nothing toward the upper dike, except that work there had been proposed in an official report, but as the report had not received the quasi indorsement of an appropriation, and no United States money had been spent, the act of Lee, in superintending the expenditure of Saint Louis money, is not sufficient to connect the United States with the work.

When suspended in December, 1839, the dike was 2,850 feet long. The upper 1,300 feet was built in a systematic manner of piles, brush, stone, and sand; the extension of 1,550 feet was a mixed mass of logs, brush, and stone, and the 950 feet built in 1840 was of stone alone. The height was 5 feet above low water (7.6 feet present standard).

During the progress of work, in 1840, the channel below the foot of the old dike which had been 7 or 8 feet deep moved down, as the dike was extended, becoming 10½ feet deep and 75 yards wide. A sand bar filled in behind the dike, and the reports of the period express satisfaction with the prospect.

Active opposition to the work does not seem to have been made in 1840; but the matter was postponed, not settled, as will appear from the following petition:

"The undersigned, being a committee appointed by the board of directors of the Madison County Ferry Company to represent certain grievances to your body as well as to arrange matters with your body in regard to those grievances, would respectfully present, that, on or about the 1st day of October, 1839, the aforesaid ferry company conceived the idea of purchasing what is called the Upper Ferry at Saint Louis from Mr. Corbin, the then owner of said ferry, and previous to such purchase waited on the city authorities of Saint Louis to know of them what they would do concerning a road from the main landing to said dike, the said dike entirely obstructing the then landing of said ferry, and the said company having received such solemn assurances that if said company would not interrupt or hinder said dike work, that they, the city authorities of Saint Louis, would in good faith build a causeway from the main shore to said dike sufficiently high for a road in low water; and whereas, said company, relying in good faith on the assurances then given, did cheerfully acquiesce in the progress of said dike, neither were they found among those who would enforce the law against the workmen on said dike, believing that the authorities aforesaid would, if they destroyed our landing in one way, make it good by making another. We believe they then intended it, and still do.

"But things have now arrived at a crisis. Our old landing is entirely destroyed by the dike, compelling us, through the course of the whole of the past season and now, to run our boat each time she crosses the river one-half mile farther than we should have done if said dike had not been made.

"We have now but a narrow channel from Brooklyn to the main channel, our only chance for ferrying without landing on Kerr's Island above the dike; and whereas the city authorities aforesaid have now in progress a continuation of said dike across said channel, and whereas if said dike should be carried a short distance farther, the said company will be subject to all the inconveniences complained of above, and whereas said grievances are too much to be borne, and with every respect for your dignity as officers and honor as gentlemen, and every respect for your feelings as fellow-citizens, our duty to our own interests compels us to say that if ample provisions are not made for the erection of said causeway, to give us a landing from the dike to the main shore, if there is protection in our civil institutions we are bound to seek it.

"But should the authorities of the city of Saint Louis consider it right, either immediately to make such causeway or to give obligations to said company that they will do so during the winter, we will bear patiently the great inconveniences we have already been subject to, and for a reasonable time hereafter, in order to cultivate good feelings between kindred interests.

"We wish an answer as soon as possible, or we will have a writ of injunction and the sheriff on the premises. If arrangements are made to the satisfaction of said company the writ will be detained in our own hands; if not, we will be in readiness to stop it instantaneously.

"We would not wish your honorable body to construe the foregoing sentiments into a menace. We intend no such thing by it, but only intend to inform you that but lit-

the more diking will stop our ferry, and what we do it is necessary that it should be done immediately.

"With sentiments of the greatest esteem, yours, &c.,

"T. G. LOFTON,
"L. B. ROBINSON,
"Committee.

"NOVEMBER 19, 1840."

This petition and that previously cited does not evince any factious opposition, but a fair, manly statement of rights, and demand that they be recognized.

The memorial was met in like spirit by the city council and referred to a select committee, who reported November 23, 1840:

"Whereas the city has built a dike nearly to the bar at the head of Bloody Island, and in a short time dike and bar will be joined, so that the ferry-boat cannot cross the Mississippi at the usual place, this committee recommend that, in justice to said ferry company, that a cross-dike be built from the present dike to the Illinois shore at or about opposite the frame house or shanty used by the United States engineers as a boarding-house; and that said dike be made under the superintendence of the city engineer."

An ordinance was reported to carry out the recommendations of the committee and the matter referred to the city engineer, Henry Kayser, with instructions that he report whether the construction of said cross-dike was embraced in the original plan of the United States engineers for the improvement of the harbor. Kayser, who had been Lee's assistant, reported that "the construction of the cross-dike, although not embraced in the original plan, was contemplated by the United States engineer. The same was to be built, at some distance below the slough, similar to that erected above the slough, and should serve to strengthen the main dike by checking the current over the dike and down the slough at high stages." A considerable bar had then been deposited between the dike and the main shore reaching down to Brooklyn. The ordinance No. 701 for a cross-dike or causeway was passed and approved December 1840, also an ordinance for the repair of the main dike.

Sundry depredations were committed about this time in the removal of material from the dike, not, however, as evincing a disposition to destroy the dike, but to obtain material for walling wells, &c.

After the passage of ordinance 701, another complication arose in January, 1841, when a memorial of the citizens of Brooklyn was addressed to the city authorities, stating that if the city would construct a cross-dike from the foot of Canal street, Brooklyn, to the main dike, in consideration thereof the citizens would forego all claims for damages on account of injury done by said main dike to the harbor of Brooklyn. This memorial is the beginning of the history of what is now known as Long Dike.

The report of City Engineer M. L. Clark, to whom the memorial was referred, is given in full as Appendix Q. It will be noticed that Clark explicitly acknowledges the justice of the claims upon which the memorial was based, and recommends the dike as a compromise, though *not a necessary* work for the improvement of the harbor.

On March 19, 1841, the Madison County Ferry Company again presented a memorial praying that the city build the cross-dike authorized by ordinance No. 701, whereupon the matter was referred to the mayor with the request that he communicate with the parties, and ascertain, if practicable, a plan for the city to adopt relative to the cross-dikes, which would reconcile the conflicting views of the ferry company and of the citizens of Brooklyn.

By act of the legislature of Illinois, approved February 17, 1841 (Session Laws 1840-'41, page 224), the Madison County Ferry Company was authorized to construct a road or causeway across the sand-bar in front of their landing, such road not to be over 40 feet wide nor more than 4 feet higher than the highest part of the bar. It is probable that this authority was obtained in the expectation that the city would do the work. The location is not fixed except by the words "from the ferry landing in Madison County."

Pending negotiations the city undertook to repair the main dike, but the work was interfered with by the citizens. However, upon promise that the city would settle all difficulties, the people allowed the worst breach in the old dike to be filled.

The final settlement of the claims of the Madison County Ferry Company was provided for by ordinance No. 805, as follows:

"Be it ordained by the city council of the city of Saint Louis, That the sum of three thousand dollars be and the same is hereby appropriated, out of any moneys in the treasury not otherwise appropriated, for the payment of damages done to the North Saint Louis and Madison Ferry Company. The auditor shall issue his warrant in favor of said company, upon their executing a receipt in full for all damages done them by the United States or by the city of Saint Louis, or that may hereafter be done them by the authorities aforesaid, in the prosecution of the works designed to improve the

harbor of Saint Louis. The company shall also enter into an obligation to expend the money hereby appropriated within the present year in improving their ferry-landing." Approved August 23, 1841.

The fact that this payment was accepted, under the conditions of the ordinance, appears from the following letter from a committee of the ferry company to—

"The Hon. the Mayor of the city of Saint Louis :

"SIR: Though the ordinance of the city council appropriating \$3,000 for the use of the Madison Ferry did not require any report from said ferry company in relation to the expenditure of said fund, yet the requisition in said ordinance that the whole amount should be expended before the close of last year seems to have predicted an intention in the city council to inquire in future whether said fund had been expended in conformity with the provisions of the ordinance. Anticipating, then, the wish of the city council, and actuated by the same spirit of good faith which characterized the conduct of the city council toward us, the undersigned, acting as a committee of said ferry company, have here annexed a statement of the manner in which said fund has been applied, and though it has proven insufficient to prosecute the work so as to make our ferry-landing as good as it was at Brooklyn, yet we would fall short of our duty were we not to acknowledge our satisfaction with the course of the city council toward us.

"Statement.

To Charles F. Stamps, for making line across Kerr's Island.....	\$1,297 50
To same for five acres of land for a ferry landing.....	100 00
To B. Robbins, for surveying the same.....	2 50
To W. Gillham and W. Wallace, for building a bridge across slough.....	1,600 00

Total amount.....	3,000 00
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"THOMAS G. LOFTAN.

"WILLIAM GILLHAM.

"VENICE, January 1, 1842.

"Copied from Journal of Board of Delegates, volume 3, pages 26 and 27. January 17, 1842."

This payment effectually secured the right of the city or the United States Government to execute all works then designed, the plans for which were well known and the location definitely fixed, the work being already far advanced. So far as the Madison County Ferry Company is concerned, or those deriving title from it, all right to a water-way, or any of the privileges incident thereto, within or east of the line defined by Lee's dike, extending from the west shore of Kerr's Island down to the head of Bloody Island, has been parted with for a valuable consideration.

This settlement with the ferry company incited the citizens of Brooklyn to submit a memorial, dated September 10, 1841, reciting—

That whereas said town of Brooklyn has been damaged by works designed to benefit Saint Louis, the damages ought to be paid. The citizens of Brooklyn, therefore, offer to submit their claims for compensation to five disinterested men—two to be appointed by said citizens, two by the city, and the fifth chosen jointly. On the payment of such sum as these arbitrators may determine, the citizens of Brooklyn "will relinquish all claims for damages sustained, or that may hereafter be sustained, in consequence of works done, or that may hereafter be done, to divert the water from the east to the west side of Bloody Island."

No action appears to have been taken upon this proposition, and the flood of 1844 made such a complete destruction of the town of Brooklyn that no one was left to prosecute the claim.

In the spring of 1842 it was reported that the west side of Kerr's Island was being washed away, and ordinance 1042 was passed August 24th, authorizing two new breakwaters and the repair of the old works. The work was deferred on account of the high prices asked for materiel.

In the spring of 1843 the engineer seems to have doubted the necessity for the spurs, and their construction was again deferred. In June a survey showed the dike detached from the bank, and much water passing behind it. As a party of United States engineers under Cram was making a survey and Congress was expected to take favorable action, the city made no effort to repair the works, which, in consequence of neglect, were well-nigh obliterated by the flood of 1844. The bridge and roadway of the ferry company were also destroyed by the flood and never restored.

The surveys made by Captain Cram in 1843 and 1844 gave rise to discussion, which seems to have continued until the existence of the appropriation of \$25,000 was forgotten. Meantime the closing of Bloody Island chute became the favorite measure, to the neglect of works above the island.

As has been shown, a compromise of conflicting interests led to the provision for a

dam at the head of Bloody Island by ordinance 1954. Said ordinance provided that the proper department of the United States Government should be requested to apply the balance of the appropriation of 1844 "to the construction of a stone dam across the eastern channel of the Mississippi, opposite St. Louis, at the head of Bloody Island, at such location and in such direction as may be deemed best." And section 4 set apart $\frac{7}{8}$ of the proceeds of \$75,000 in bonds to be used for the "continuation and completion of the stone dam at the head of Bloody Island," to be commenced by the United States as mentioned in section 2.

The language of the ordinance seems unmistakable, that a new dike, direct across the chute at the head of the island, was intended, and the newspapers of the time confirm this interpretation. Yet in his message, July 3, 1848, Mayor Krum, speaking of the works provided for by ordinance 1954, says: "Said works are to consist, first, in the continuation and completion of the stone dam at the head of Bloody Island commenced by the United States Government." The omission of the words *to be* in this quotation changed the sense materially, as with this omission the language can be construed to mean Lee's dike. Later in the message the mayor says: "The work for the repair and continuation of the dam at the head of Bloody Island has not been commenced."

During the pendency of the injunction suit as to the lower dike an attempt was made to repair the old Kerr's Island work. "The water being low, all the stone was applied in repairing the old work done by the United States, which was to constitute a portion of said dam, and could then be traced with accuracy." (Kayser's report, November, 1848.) When these repairs had progressed to the lower end of the 1,300 feet actually built by Lee, the contractor was arrested by authority of the governor of Illinois on a charge of obstructing the navigable channel of the Mississippi, but the court did not sustain the charge.

The joint resolutions of the legislature of Illinois of February 9, 1849, obviously intended to guard the rights and promote the interests of the ferry and coal companies by requiring the construction of the cross-dikes W and V, extending from the main Illinois shore to "the main dike from Bloody Island to Venice." It would be difficult to say from the language of the resolutions that it was intended that the city should be required to construct not only the cross-dikes, but also to complete the longitudinal dike from Kerr's Island to the head of Bloody Island, were it not that the universal interpretation at the time was that this dike was included, and is believed to have been named in the bond given by Saint Louis to secure the faithful performance of the conditions imposed. Why this seeming misconstruction of ordinance 1954 was allowed to obtain is unexplained; possibly the interest some must have felt in the defeat of the upper roadway scheme may be the explanation. What was considered to be required by the resolutions is discussed by Kayser in his report of February 26, 1849. (See Appendix L.)

Although the dike or dam from Kerr's Island to Bloody Island had been projected many years, the necessity for its construction does not seem to have been questioned until Curtis, in his report of October 10, 1850 (Appendix O), gave reasons which in his mind rendered it advisable to procure a release from the bond and agreement to build it. It has not been practicable to trace the bond to determine whether such release was formally made, the papers not being found in the city register's office. The dike was never built, nor did the old part receive any repairs, so far as the records show. In 1851 some stone was reported placed at the head of Bloody Island. Probably this is the detached body of rock shown above the present head of the island on the authority of the map of 1861. The cross-dikes W and V, at Brooklyn and Venice, were begun and carried out to their full length in 1850, and have since been repaired from time to time.

In a report made July 3, 1855, mention was made of the need of a dike opposite Bissell's Point to prevent abrasion, which recommendation was repeated several times, and then dropped to make way for the Grand Chain dike, and the project of turning the river east of Cabaret Island. When that costly experiment was abandoned—at the death of Homer—the construction of a dike opposite Bissell's Point, or rather the extension of an old dike (as the map of 1861 shows a spur at the exact locality), was commenced, and had progressed so far in October, 1867, that it was reported "the northern part of the harbor had changed much, and when the dike was made six feet higher, and the old dikes repaired and extended so as to make the river from 1,600 to 1,800 feet wide, all the bars will be cleared out."

This dike, which is known as Bischoff's, now stands as the most northerly work upon the Illinois shore. It is upon the land owned by the Madison County Ferry Company, and is guarded by the terms of an agreement made by ordinance 6817, between the City of Saint Louis and the Ferry Company, as follows:

Sections 1, 2, 3, and 4 grant certain privileges to the North Missouri Railroad Company and the Madison County Ferry Company. Section 5, "The foregoing privileges are granted to the Madison County Ferry Company upon condition that the said corporation will permit the city of Saint Louis to erect and maintain such dikes on the

lands belonging to them at or near Venice, in the State of Illinois, as may be judged necessary by the proper authorities of the city of Saint Louis, for the protection and improvement of the harbor of said city. And acceptance of the privileges hereby granted to said corporation by it shall be deemed a grant to the city of Saint Louis to build and maintain such dikes on its property aforesaid." Approved March 19, 1869.

The construction of Bischoff's dike brings the history of the works in this vicinity down to the time when the Board of United States Engineers made their report in 1872. As none of the reports and documents here cited were before the board, except the reports of Captain Allen upon the surveys of 1870 and 1871, and probably a copy of Merrill's report to the city in 1869, the board had no means of knowing that serious legal questions were involved, and no one was at the pains to enlighten them. The engineering questions were also involved in much obscurity, as has already been shown.

Works for the improvement of the lower harbor were begun about 1843 to 1846, by the construction of dikes or embankments at Mulberry and Hazel streets, with a view to extend the wharf south from Market street. The results gave confidence in the ability to reclaim ground from the river.

In 1849, among other recommendations, a dike opposite Duncan's Island, above the mouth of Cahokia Creek, was proposed (see Appendix L), to wash away the west side of Duncan's Island, and to induce deposit in the channel then following the bend above Cahokia. This recommendation was indorsed by S. R. Curtis in December, 1850, who suggested that the dike be given an inclined profile from the top of the high bank to the low-water level at the outer end of the dike. He also proposed a new mode of construction to avoid the scour and settling that had attended the use of riprap only. Curtis's plan was to drive two rows of piles four feet apart and piles spaced two feet apart in the rows and to lace or interlock brush with the piles.

The dike was commenced in the spring of 1851, and at the time of the flood was 400 feet long. As it stood without damage, the success of the new plan was considered demonstrated. During the fall of 1851 the length was extended to 600 feet, when the depth became so great as to require piles 50 or 60 feet in length, implying a depth of water of about 40 feet. This dike was usually described as being opposite Lesperance street and below the mouth of Cahokia Creek. The survey of 1861 locates a dike—probably this, as no other is mentioned in the records—opposite Miller street. It is now effectually buried in the deposits below the Illinois and Saint Louis Railroad dike.

The Illinois and Saint Louis Railroad, commonly called the Pittsburgh, dike was built by the railroad company, after several attempts, in 1865; it is an earth embankment with riprapped sides and a mass of riprap at the outer end. Its height in 1866 was 4 feet below the city directrix; it has probably been raised since. The dike was built mostly over dry bar. The outer end was laid on dry bar, 3 feet above the water, in January, 1865. In 1875 the water in June was 70 feet in depth at the same place. The result of this dike has been the filling up to a height above ordinary water of a large area below, and a much larger extent of high bar protected by the dike reaches from the foot of Bloody Island to below Cahokia. In front of the village of Cahokia a dike with two branches was visible a few years since, but is now buried with sand. The efforts of the Cahokia Ferry Company to maintain a roadway at low water have aided the growth of the bar. Lines of willows resting in trenches and the tops leaning with the current have served a good purpose in inducing deposits.

The railroad embankment and incline opposite South Saint Louis (formerly Carondelet) was built in 1873. Heretofore this embankment has had the protection of a large extent of high bar above, but the changes which have occurred at Arsenal Island have deprived it in a great part of this protection, and its maintenance will now become more difficult.

Below the railroad is the dike of the Carondelet Ferry, which was completed as a wagon-road embankment in 1877. It is entirely secure so long as the railroad above is maintained.

Opposite the extreme south end of the city is the trestle-work of the Cairo and Saint Louis Railroad. Though but an open trestle, the accumulation of driftwood has formed a tangled mass which, now that it is buried in sand, may be considered immovable, rendering the permanence of the accretion reasonably secure.

In the preceding review of the history of the works for the improvement of Saint Louis Harbor no notice has been taken of the numerous dikes on the Saint Louis side, which really were harbor works, as their purpose was the reclamation of ground. Such dikes were at various times built at the inlet tower of the water-works: Bremen avenue, Destrahan street, Montgomery street, North Market street, Labaume street, Mound street, Florida street, Mulberry street, Hazel street (Chouteau avenue), Rutger street, Lesperance street, Miller street, Bartow street, Anna street, Bryan street, Olive street, Carondelet.

The dike at the Chain of Rocks has received mention so frequently, that no necessity exists for a special statement of the object it was intended to serve. As a work, it need only be said to have been constructed of riprap; a considerable part of the dike remains visible; being built on rock foundation, fully one-half of the longitudinal por-

tion has disappeared entirely, that is, has sunk so low that the sand covers it, and no ripple marks its site.

Reviewing the history of this long-continued series of engineering works, it would be inexcusable to neglect the opportunity to gather up the practical lessons that have come under notice; lessons, some of them, which have been learned again and again by successive generations of engineers, whereas one experience ought to have been enough, and would have been, if the experience gained had been handed down.

So far as general principles are concerned, there appears to have been but two systems or plans proposed: First, that meeting the difficulty directly and endeavoring to overcome it by means of local works; second, that which, with greater show of science, sought for the causes of the difficulty even at remote points, and proposed to remove or control the causes. The latter has the appearance of being the more rational course; but, when consideration is given to the difficulty of tracing results back to their causes in complicated cases, it is to be expected that great differences of opinion and plan will be found among those who attempt it.

Accordingly, we find in the reports of this school propositions widely differing, such as: To divert the Missouri by a direct cut into the Mississippi near Portage Des Sioux. To check erosions opposite the mouth of the Missouri. To divert a varying proportion of the water to the east side of Cabaret Island; and even to cut a canal across the point above the city, following, approximately, the course of Gingrass Creek. Of these various schemes the diversion of a portion of the river to the east of Cabaret Island was the favorite.

At that time there seemed to be no objection made to a division of the water as likely to produce a difficulty in the form of shoal water; therefore none of the projectors proposed to close the west chute and turn the whole low-water river to the east of the island. Moreover, there seems to have been a belief that water followed the laws of elastic solids and light, as to the angle of reflection being equal to the angle of incidence; consequently frequent mention is made of resultant directions and reflected direction.

Lee avoids all mention of the project for work at the Chain of Rocks, and confined his plans to meeting the questions presented in the harbor itself. His works are both of the nature of longitudinal training walls or dikes parallel to the current. The upper ends were connected with the natural bank of the island, and, in the case of the upper dike, the plan included cross-dikes to the main shore at intervals, to prevent the current getting upon the inside of the dike. So far as Lee conducted the work he seems to have made the construction of the longitudinal and cross dikes simultaneous; for the 1,300 feet he built was connected at both ends with the shore. Lee's plan of construction was an elaborate one, and was faithfully carried out. The results, therefore, furnish a fair test of the system after making due allowance for the fact that the work was never completed. The pier at the foot of Bloody Island was for a great part of its length built in shoal water, if not upon a bar above the level of low water. When the upper dike was extended by Kayser, the first 1,550 feet was built of logs, brush, and stone, evidently a departure from the careful, systematic construction of Lee; and in a subsequent extension by Kayser 950 feet was built of stone only. The part built by Lee was repaired several times, while the repair of that built by the city was prevented.

The connection of the upper end with the shore was impaired by the removal of stone, and the preservation of the connection by needed auxiliary works was neglected. Consequently, in 1843 the dike was cut off from the shore and a current allowed to run behind it.

Cram reported that in November, 1843, 1,200 feet at the upper end had sunk 4½ feet, or had been swept away; the next 1,100 feet was destroyed or had sunk 11 feet; the next 435 feet destroyed or sunk 9½ feet; and the remaining 1,265 feet must have sunk 15 feet. These statements are based upon soundings taken at a stage 8.75 feet above low water (11.35 present standard), and give no certain indication of the real facts. Later, Cram said the flood of 1844 left no vestige of Lee's work in existence; probably they were buried out of sight, for Kayser, in November, 1848, states "that the dam can now be traced with accuracy." In that year Lee's part was again partially repaired. In 1861 the survey found 970 feet of dike uncovered, of which 860 was upon the foundation built by Lee. We learn, then, that Lee's work was stable, though by neglect exposed to currents upon both sides. The more carelessly built parts seem to have passed beyond certain knowledge in 1843.

The survey of 1877 shows the point of dry bar extending to about 100 feet below the end of Lee's work, and a decided ridge is shown by the soundings to run upon the line of the old work down nearly to the end of the 1,550 feet of mixed logs, brush, and stone, while below the soundings give no hint of trace of the 950 feet built of stone only. The pier at foot of Bloody Island passed through a history like the above. The upper part was undermined in 1840, while that founded in deep water remains traceable to this day. The repairs previous to 1849 were frequent and extensive, but it is nowhere said that the foundations failed. Later experience supports the conclusion

that brush, properly treated, furnishes an economical and durable material for dikes when laid at a suitable depth, even upon the shifting, sandy bottom of the Mississippi.

The stability of training walls we also learn depends upon keeping them from exposure to a current parallel to their direction, particularly on the inner side.

Cross-dikes have proved necessary adjuncts of longitudinal walls. When such have been built and maintained, the permanent reclamation of large areas has been successfully accomplished in reasonable time, and in some cases at moderate cost.

Where the cross-dikes have extended beyond the line of the longitudinal wall, they have served to protect that wall from undermining, even when the depth of foundations was small.

Cross-dikes, inside the longitudinal wall, in profile should be either a high level with an incline at the outer end, or an incline reaching from the outer end to the top of the high bank against which the dike rests.

When reclamation is the object, construction may progress too rapidly, if the dike be of a height above ordinary high waters. In interest of economy of construction the extension to the full length designed cannot be done too rapidly.

Unfortunately the rights of riparian owners have never been fully defined by statute. The few decisions on record have mostly been based on English precedents, and therefore upon supposed analogy between very unlike cases. Navigable waters, according to English definition, are coincident with the ebb and flow of the tide.

In America it is established law that the right of the public to use waters for navigation is determined by the possibility of so doing, and when existing, as a matter of fact, is not subject to the will of owners of contiguous property.

In the case of waters forming the boundary between States, the center of the main channel, as said channel existed at the time the boundary was defined by creating a separate State or Territory, is and remains the legal boundary so far as right of civil jurisdiction is concerned. Joint criminal jurisdiction is acknowledged over offenses committed upon the waters.

The soil under navigable waters is considered to be the property of the several adjoining States. Nevertheless, in case of the formation of an island, a survey will be made on application and a patent issued from the United States Land Department, the same as for lands on shore for which no claim of ownership by the States has ever been acknowledged. Also, in case of accretion, the right of ownership is ordinarily considered to extend to low-water mark without limit. Under such circumstances the ownership of the bed of navigable waters by the States is little more than a legal fiction; but if the States should undertake also to grant rights, complications might arise to determine the limitation of such rights.

Upon the borders of the Mississippi land titles originate in grants made under the governments from which the territory was acquired, confirmed by patent, or in simple patents for purchased land. The old grants were located without fixed system, and, when bordering upon navigable streams, carry riparian rights under guarantee, it is commonly believed, of the treaty of acquisition. The lands held by simple patent have no legally defined riparian rights. Partly under the guidance of legal decisions made by courts, considering only conflicting proprietary claims, and partly governed by custom, surveyors have been accustomed to survey properties bordering upon the river, either by prolonging the original boundary lines to the new water's edge, or, as obtains in some sections, by running from the end of the old boundary, at the old margin of the river, a line across the accretion at right angles to the general direction of the current. The former practice has the merit of being definite and uniform in result whoever makes the survey and whenever made; the latter involves two uncertainties.

First. The varying direction the current takes at different times. Second, The varying skill or good judgment of the surveyor in determining the direction of the current. A few minutes' consideration will suffice to show the impropriety of the latter method, as it must inevitably lead to dispute whenever the land becomes of value.

The practice here criticised is particularly inappropriate, when the title is derived directly from the United States, for lands subdivided under the general system. Consistency in these cases demands that lines should be extended over accretions as meridians and parallels, and that rights to accretions should be limited to the completion of the subdivision which the title describes as fractional. Aside from the question of ownership of accretions, riparian rights include also the privilege of extending piers and landings across shoals to navigable water. The recognition of this right is natural and proper in tidal waters; but in rivers the right cannot be allowed in all cases or without limitation. In rivers, this right, to be of value, must cover access to the low-water channel, and the difficulty arises from the fact that the exercise of this right is opposed to the great office of a river, drainage, to which all rights of use for other purposes must be subservient in law, as they are in fact and nature. A pier built to afford access to the low-water channel will oftentimes contract the water-way to a degree interfering with the passage of flood waters, and consequently cause damage to neigh-

boring property, or will create a local current past the obstruction which interferes with, and may even suspend, the navigability of the stream at certain stages.

An actual instance will illustrate this point, and show the necessity for some legislative restriction of such rights. In front of South Saint Louis the river is very deep, and the deepest water is along the Missouri shore. The city has established a wharf line, which, being tangent to the natural rocky shore at two points, encroaches as little as is possible upon the bed of the river. On the Illinois side is an extensive sand-bar, dry at low or ordinary stages, extending to within 1,600 feet of the Missouri shore. The East Saint Louis and Carondelet Railroad, the Waterloo Turnpike, and the Saint Louis and Cairo Railroad, necessarily must cross this bar and be extended to navigable water in order to make ferry connection with Saint Louis, a necessary and wholly proper purpose. Previous to 1877 the inclines and pier heads of these roads were terminated 1,500 feet from the wharf front of Saint Louis. In that year the growth of the bar compelled each of these interests to extend their works until they are now as follows: East Saint Louis and Carondelet Railroad, 1,050 feet; East Carondelet Ferry dike, 1,150 feet; Saint Louis and Cairo Railroad coal dump, 1,300 feet, from the established wharf line.

It has already been shown that the Mississippi cannot safely be narrowed to this width in time of flood; but even at ordinary stages this part of the river has been a difficult place for upbound tow-boats to pass, owing to the fierce current. They have been able to stem it only by following the edge of the sand-bar on the Illinois side, which it will now be impossible for them to do, if the works recently built remain.

This case serves to show the need of careful legislation to define the rights of riparian owners and others upon the Mississippi. In important tidal harbors the time always comes when unlimited individual right of access to navigable water must give way to the more general rights of the community by the establishment of limits to encroachment. Similar interposition of the highest power of the land seems to be called for now to establish limits in front of Saint Louis, and ere long similar interference will be necessary at other points.

This definition of legal rights is also necessary to the prosecution of the work of improving the river, for at every step questions are liable to arise which cannot safely be left to chance, or the discretion of whoever may be for the time in charge of such work, for every work, whatever may be its object or plan, will either benefit or injure the interests of some property owner in the vicinity. If a front be protected, the benefit is direct and little will be said. If a chute is to be closed, a wide reach narrowed, or a channel defined, then some man's land will be cut off from the privilege of access to navigable water, constructively if not really, and claims for damages are sure to follow.

The presentation of these questions in connection with the improvement of Saint Louis Harbor is fortunate in this respect at least: the value of the property and the magnitude of the interests involved make the question as here presented the most important which can arise, and therefore the decision will be carefully scrutinized, and, when final, will settle others as a precedent.

A.

EXTRACT FROM LETTER OF GENERAL C. GRATIOT, CHIEF ENGINEER.

ENGINEER DEPARTMENT,
Washington, April 16, 1834.

GENTLEMEN: I have carefully examined the map of that part of the Mississippi River in the immediate vicinity of Saint Louis, drawn by Mr. Eiler, with the view to project a work or works for the removal of the sand-bar in front of the city. The bar can doubtless be removed; but in addition to the uncertainty with regard to the result involved in the erection of almost all hydraulic works for the improvement of the bed of running streams, the case in question presents difficulties of no ordinary character. These arise principally from the large volume of water, its great velocity, and the almost mercurial nature of its bed, which melts and yields to every variety of current produced by frequent fluctuations in the stage of the river; and I am satisfied, after a patient consideration of the circumstances, as far as they can be drawn from the map, and conversations with those acquainted with the locality, that any structure, however well devised or judiciously located, must be executed with extreme caution to produce the desired end. Just below the foot of Cascarot Island, where the whole body of the river passes through a narrow gorge, by far the greater portion of the water runs along the right bank, and in entering the gorge has a direction which carries a large part of it to the left shore, along which it sweeps with violence till it reaches a point below the city. The rest continues on the right bank, and

passes into the bend which terminates in a projecting point of rocks at the upper part of the city, where the direction of the current is diagonally across the river between the bar in question and Bloody Island. Below the gorge referred to the banks recede from each other rapidly; the water is spread over a greater surface, its velocity is checked, and down go the sand and mud with which it was surcharged in passing the gorge. Hence the formation of Bloody Island, which is represented on the map as extending nearly to the gorge, presenting the appearance of a wedge dividing the body of water as it passes through. The water that follows the right bank is somewhat confined till it reaches the foot of Bloody Island. Here its change of direction produces slack water and eddies on the shoal below, and hence the constant augmentation of the bar, which is rapidly making its way to the island, with which, unless prevented, it will one day form a natural dam that must ultimately throw the main body of the river on the left bank. The left bank, being alluvial, is constantly dissolving under the action of the current and washing away, and as the channel passes immediately along shore, this will hasten the result referred to.

In order to remedy the evil and render the cure permanent, it will be necessary to arrest the present tendency of the current and throw it on the right bank after it passes the gorge, and so to direct it below Bloody Island as to cause it to act on the bar. The first may be effected in one of two ways, the choice of which will perhaps depend upon the disposition of the people of Illinois. The first would be to erect a wing-dam on the Illinois shore, near the mouth of the small slue which returns to the river at the upper ferry landing, at A. (See map.) The dam should be constructed on a line drawn from the mouth of the slue tangent to the western side of Bloody Island and extended sufficiently far to produce the desired effect. The second would be to erect a similar work on the Missouri shore just above the foot of Chouteau's Island, at a point (C) about half-way between Burt's and Duncan's, to throw the body of the water into the large slue that passes to the east of Cascarot Island. This would wash out that channel and give the mass of the water a tendency to take the right bank, after passing the gorge at the foot of the island, just as it now has a tendency to follow the Illinois shore. If it should be found that the bar in front of the city is of sufficient consistence to resist the current thus created on the Saint Louis shore, it will be necessary to erect a wing-dam (B) at the foot of Bloody Island. This dam should be constructed on the prolongation of the western face of the island, and continued gradually in a gentle curve parallel to the right bank till the whole force of the water is made to act on the bar. It is considered, however, highly important that this structure should not be commenced till one of the dams above shall be nearly completed. One of the essential elements of this problem is the preservation of Bloody Island; it will be proper, therefore, that its head and western margin should be well fortified, the works (E, D, F) for which should be conducted simultaneously with the construction of the upper dam.

Since drawing up this project, I have conversed on the subject with Captain Shreve, whose great experience in works of this character on the western waters entitles his views to great consideration and weight. He is of opinion that the wing-dam A should leave the Illinois bank at R and run directly across the eastern channel, and envelop the head of Bloody Island; and be prolonged on the western margin of that island sufficiently to protect it from the wash. He then recommends that a small dam should be constructed at right angles to the current at S on Bloody Island, and be projected into the channel as far as may be deemed necessary, to concentrate the section of the water upon the bar to be removed. These views are received with a deference due to the great judgment and ability evinced in the prosecution of the numerous works with which Captain Shreve has been charged, yet they do not seem sufficiently strong to require me to act upon them to the exclusion of those before presented.

Very respectfully, I am, gentlemen, your obedient servant,

C. GRATIOT,
Chief Engineer.

Hon. L. F. LINN,
Of the Senate, and
Hon. WILLIAM H. ASHLEY,
Of the House of Representatives.

B.

EXTRACT FROM REPORT OF LIEUT. ROBERT E. LEE, CORPS OF ENGINEERS.

SAINT LOUIS, *December 6, 1837.*

SIR:

* * * * *

HARBOR OF SAINT LOUIS.

The appropriation for the improvement of this harbor has for its object the removal of a large sand-bar occupying below the city the former position of the main channel of the Mississippi, which, gradually augmenting for many years, has now become an island of more than 200 acres in extent, covered with a growth of young cottonwood, and reaching from the lower part of Saint Louis, which it shuts out from the river, to 2 miles below. The extensive shoals formed around its base extend on the east to the middle of the river, and, connecting with the main on the west, afford at low water a dry communication between. A flat bar projects from the upper end to the foot of Bloody Island, opposite the town, which at low stages of the river presents an obstacle to approach of the city, and gives reason to apprehend that at some future day this passage may be closed. This is rendered more probable by the course of the river above, and can be better explained by reference to the accompanying map. The united waters of the Missouri and Mississippi for some miles below their junction sweep with great velocity along the Illinois shore, when they are deflected to the Missouri side. The mainbody, passing west of Cascaret Island, joins with the lesser portion at its foot, and the whole is compressed between the narrow gorge V, VI. Spreading out in the wide area below, the main current still keeps to the Missouri shore, while a large part of the river directed toward the Illinois side is fast wearing away its bank and cutting out a large channel.

Further apprehension is also afforded from the formation of this part of the bank, which has a fall to Cahokia Creek that runs within a short distance. But an inspection of the map will at once show the tendency of the river to this course, both from the direction of the deep water issuing from the gorge above as well as the location of the large shoal extending from the head of Bloody Island.

It will also be seen that wherever the bed of the river is sufficiently contracted a regular and deep channel is formed by the current, and that this is interrupted when the water is spread over too large a surface; that the greater part of the river enters the gorge at V, VI, close to the Missouri shore; and while the mean depth is in the middle all the shoal water is on the east side and all the deep on the west. Passing around in the bend below, the deepest water still keeps to the Missouri side; and in the narrow section between the city and Bloody Island all the deep water is found, as before, on that side, and all the shoal on the opposite. From this point the current is deflected from the Missouri shore, and its velocity is so far diminished by the time it reaches the foot of the island, from the expansion of its bed, that the abrasion of the bottom ceases; the earthy matter with which it is surcharged subsides, creating by its deposit the bar and Duncan's Island. The two channels again uniting at the foot of Bloody Island, the whole body of water sweeps down the Illinois shore; and its velocity becoming again increased by the narrowing of its bed, the abrasion of the bottom recommences, all the deep water being here on the Illinois side, and all the shoal on that of Duncan's Island spreading out below, the depth of the channel soon diminishes; and dividing at the head of the bar, extending from Cahokia Island, the main current still keeps to the Illinois shore until having passed its foot. It is, therefore, evident that it is only necessary to concentrate the current wherever the channel requires to be deepened; that the branch of the river which passes between the city and Bloody Island has a velocity sufficient to excavate the bed to the depth of 39 feet below low-water level; that this depth continues as far as the section continues, and would, in all probability, extend if the section were lengthened; moreover, that this is sufficient without the aid of that branch passing east of Bloody Island, which, therefore, is not necessary to divert this effect. But in order to arrest the wearing away of the eastern bank of the river, and to protect the Illinois shore, it will be necessary to divert from it the force of the current. This may be done by running a dike from above the small slough on that side parallel to the western shore sufficiently far to throw the water west of Bloody Island.

The distance from where the dike would have to be commenced to the head of Bloody Island is 1.5 miles, and the length of the dike would require to be equal to one-half this distance, or three-quarters of a mile, and might be obliged to be extended the whole way. The same effect would be produced by throwing a dam directly across from the head of Bloody Island to the Illinois shore; the dead water created by which would extend as high as the point above the slough, and by its resistance throw the

great body of the river into the Missouri channel. This will also bring a greater volume of water to bear upon the bar and head of Duncan's Island; and by constructing a dike from the foot of Bloody Island parallel to the shore in front of the city, and of sufficient length, it will receive the proper direction. A cross-section of the proposed dam and dike is shown on the map, which are similar to those constructed on the Hudson River.

The length of the dam will require to be 594 yards, and its height 5 feet above low water level; its width on top is 10 feet, having its exterior slopes equal, and 3 of horizontal to 1 of vertical height. A row of piles, 5 feet from center to center, are driven firmly into the bed of the river, at the intersection of the slopes with the plane of low water. Brush of proper length, to extend well toward the toe of the slopes, with their butts and branches so interwoven with the piles as to be held firmly in place and form a complete matting, is laid at right angles with the direction of the dike, and sunk to the bed of the river with large stones. This is carried up as high as low-water level, the interior filled in with small stones, sand, fascines, &c., and the slopes and crest above this plane revetted with stones placed on their edges, and well bound together, so as to form a revetment of from one foot and a half to two feet thick. The slopes below the plane of low water are secured by throwing stones promiscuously over and distributing them as equally as possible.

The length of the dike, as laid down on the map, is 1,000 yards; it will probably require not to be less than this, but must be determined by its effect. Its height above low water will be five feet, and the plan and mode of construction are the same as were described for the dam. In addition to these works, the western shore of Bloody Island will have to be protected from its head to the center, so as to secure it against the action of the current.

The erection of these works will be attended with great difficulty.

The whole bed of the river is composed of the alluvial matter brought down by the Missouri, consisting of a light loam, mixed with the finest sand, which melts and yields to every pressure of the current. Its depth must be at least forty feet below low water level, and has so little stability as to be changed by every flood. Besides the unfavorable foundation, the great velocity of the Mississippi, its violence during the spring freshets, and the short season for operations present impediments so great that, in addition to the uncertainty always connected with hydraulic architecture, the result cannot be predicted. The plan proposed appears to me the best calculated to accomplish the end in view; but how far it may be successful, or what modifications it may require, can only be shown by experience. Neither can the estimate of its probable cost be stated with any degree of certainty, or be considered more than conjectural, and embraces merely the prices of the required materials and labor, with the necessary boats and machinery, and the incidental expenses that can be foreseen.

All of which is respectfully submitted.

R. E. LEE,
Lieutenant Engineers.

Gen. C. GRATIOT,
Chief Engineer.

C.

EXTRACT FROM REPORT OF CAPT. ROBERT E. LEE, CORPS OF ENGINEERS.

SAINT LOUIS, 24th October, 1838.

SIR:

* * * * *

II. THE ERECTION OF A PIER IN THE MISSISSIPPI RIVER, NEAR SAINT LOUIS.

The construction of the pier, running from near the foot of Bloody Island, parallel to the Saint Louis shore, was commenced early in June. The river was then 11 feet above low-water level, and continued high until September. The pier, though not completed throughout its whole extent, has been extended as low down as opposite Market street. It has been constructed in the manner proposed in the plan submitted last year. The piles have been driven from 12 to 17 feet into the bed of the river. The brush extends from 30 to 40 feet from the foot of the piles, and the exterior slope is 3 to 1. The settlement of the pier has been but slight, and there is now no indication of its want of permanency. Within 1,200 feet of its extremity it is only raised a foot above low-water, and has to be carried 4 feet higher. It is yet too soon to speak of its effects. It has, however, so far served to protect the shoal extending from the foot of Bloody Island, and to confine the current as far as its extremity to the city

shore. About 700 feet above Duncan's Island, estimating from low-water mark, has been washed off. The channel across the flat bar between Bloody and Duncan's Islands has deepened 7 feet, and boats not drawing more than 2 fathoms can, at low-water, keep a direct course from the mouth of Cahokia Creek to the foot of Walnut street. On the other or eastern side of the pier a contrary result is perceptible. The water of the western channel being diverted by the pier, allows that passing east of the island to spread over a greater surface. Its velocity is accordingly diminished and a deposit has taken place. For about half a mile below the foot of the pier, the former channel along the Illinois shore has filled up, and where last fall there was 18 feet at low-water, there are now but 6 feet. A greater body of water than formerly is also thrown west of Cahokia Island, and is wearing away the shoal at the foot of Duncan's Island. There are now two fathoms at low-water through that pass, excepting over a narrow bar connecting Duncan's and Cahokia Islands, where there is but *one* fathom.

These changes in the lower part of the harbor, you will perceive, can produce but little effect in that above unless we consider the benefits derived from an improved water-way west of Bloody Island and consequently a greater draught through that channel. The large shoal extending from the head of Bloody Island into the bend above the city, and adverted to in my last report, still exists.

During the past winter it arrested the descending ice which, forming a barrier across its point, seemed to turn nearly the whole current east of Bloody Island. The channel on that side has been consequently enlarged in depth and width. A similar occurrence may be apprehended this winter and be attended with a similar effect, and confirms the necessity of diverting the current from that shore. By throwing the dam across from the head of Bloody Island, as proposed last year, this may be effected; but from my experience the past season, I apprehend greater difficulty in its construction and have more fears of its permanency than if it was commenced from the point above the dry slough and run directly to the head of Bloody Island. It will in this case not only serve to protect the Illinois shore and throw a greater body of water west of Bloody Island, but to contract that section of the river and produce a better channel across the shoal, which at lower water is becoming a serious impediment to the navigation and also tend to diminish any evil that might result from the breaking up of the ice during low water. The construction of the dam as first proposed may, by causing a deposit along the shore above, produce the effect anticipated from the direction now recommended, but the fall of the river is so considerable and the velocity of the current so great that the *dead water* will not probably extend far above the dam and leave room to apprehend the continuance of the abrasion of the bank above, which in time would wear a passage around the end of the dam.

Although the direction now proposed will add greatly to the length of the dam its cost will not be proportionally increased. It will extend along on the shoal from the head of Bloody Island, where the depth of the water varies from 1 to 5 feet, except where it crosses the channel, the greatest depth of which does not exceed 12 feet, and will avoid the deep water east of Bloody Island, which is 22 feet at low water. I therefore beg leave to recommend that the plan submitted last year to the Department may be so modified as to substitute the dam now described for that there proposed.

The accompanying map will show the relative position of these dams as well as the direction and length of the dike at the foot of the island, the extent of the shoals and bars exhibited at low water, the changes in the channel, &c., &c.

All of which is respectfully submitted.

R. E. LEE,
Captain Engineers.

Gen. C. GRATIOT, *Chief Engineer.*

D.

EXTRACT FROM REPORT OF CAPTAIN ROBERT E. LEE, CORPS OF ENGINEERS.

SAINT LOUIS, October 21, 1839.

SIR: I have the honor to submit the following report of the operations at the works under my superintendence:

2. THE ERECTION OF A PIER IN THE MISSISSIPPI RIVER NEAR SAINT LOUIS.

Before the small balance that I reported unexpended on the 30th of September, 1838, was entirely consumed, the citizens of Saint Louis desiring the speedy completion of the work voluntarily advanced \$15,000 in anticipation of a further appropriation by

Congress, which they placed at my disposal that I might not lose the advantages of the favorable season that then existed.

Operations were accordingly continued until they were arrested by the closing of the river by ice. No appropriation having been made for 1839, and having been desired by the mayor to apply the residue of the sum supplied by the city, preparations were made to resume the work at the season of low water.

As soon as the stage of the river would permit, operations were commenced on the pier from the Illinois shore above Bloody Island, and continued from the 12th August until the 27th, when they were arrested by a writ of injunction, issued upon the order of the judge of the second judicial circuit of the State of Illinois. I immediately referred the matter to the United States attorney for the district of Illinois, with a request that he would take such steps to dissolve the injunction as the laws would authorize. I have already reported to you the circumstances of the case and transmitted the papers connected therewith, from which you will perceive that it is as yet doubtful whether the question can be decided before the regular term of the court in February next.

The accompanying map C will show the progress of the work as well as the changes that have taken place in that portion of the river they were designed to affect. It has been prepared with care, with a view to institute a comparison between its present and former condition. The pier from the foot of Bloody Island as yet remains firm and permanent. A large deposit has taken place around and upon it, so that only a portion of its lower end is now visible. The contraction of the river has caused it to wear a deeper bed. The bar that projected into the harbor from the head of Duncan's Island is entirely removed, and there is now 15 feet water where it was formerly dry at the same stage of the river. The influence of the increased velocity of the current has also been felt below the foot of the pier. Directed against the head of Duncan's Island upward of 300 feet of that part above high-water mark has been washed away, together with a section of more than 100 feet wide along its eastern face. Of the bar above low-water mark 1,700 feet of that part that extended up the river and 800 feet of its eastern side has been carried away, and there is now a channel more than two fathoms deep across the shoal between the foot of Bloody Island and the head of Duncan's Island, where it was formerly dry when the river was 6 feet above low-water level. The resistance opposed by Duncan's Island at length deflects the current to the Illinois shore, whence, rebounding with an equal angle, the great body of it is thrown into the channel west of Cahokia Island, and has washed away about 1,000 feet of the tail of Duncan's Island. This passage is becoming the main channel of the river. It is widening and deepening daily, and contains more water than that east of Cahokia Island.

The upper pier commences at a point on the Illinois shore, where it is struck by the river after leaving *Sawyer's Bend*, and runs in a straight line to the head of Bloody Island, the head of the pier being the same distance from the Missouri shore as the head of Bloody Island is from the city shore. It extends as far down as the *dry slough*, a distance of 1,300 feet, where it is intersected by a dam from the shore intended to arrest the sediment from the river and form a solid abutment. It is constructed with stone and brush in the same manner as the lower pier, except that one row of piles is used at this part of it instead of two. Last fall the piles were driven as far down as this same point, and terminated on the tail of a bar that lay a little to the west (see drawing accompanying last annual report), but cold weather commenced early in November; the boats were so retarded by the running ice that only a portion of them could be filled in with stone. The ice accumulating against the pier thus partially constructed formed a barrier from the shore to the bar, which had a tendency to divert the current into the channel west of Bloody Island, until the large cakes of ice grounding on the bar extending from the head of Bloody Island toward the Missouri shore blocked up that channel, when the pressure against the pier became so great that the lower portion where the piles were not supported by stone gave way and the whole river passed east of Bloody Island. The pier being now formed as high as low-water level produces a similar effect, and by the contraction of the river at this point the same process is going on that has occurred at the lower pier. An inspection of the map will show you that a channel 1,000 feet wide and varying from 1 to 2 fathoms deep has been cut through the upper end of the bar from the head of Bloody Island, where it was last year dry, giving a straight course down the river, and is separated from the old channel close to the Missouri shore, but 300 feet wide, by a portion of the upper extremity of the bar which still remains. The channel to the east of Bloody Island has diminished in a proportionate ratio. The head of the bar points to the Illinois instead of the Missouri shore, and the great body of the river flows by the city. To continue and render permanent this favorable action of the current it will be necessary to complete the plan of improvement that has been adopted. The delay that has occurred this season for want of funds may, besides increasing the eventual cost, be productive of much injury. Both piers will be exposed in an unfinished state to the almost resistless force of the river another winter and spring, and things

may be found next year in a very different condition from that in which they are now left. The opposition raised by one of the proprietors of the Brooklyn is, in my opinion, upon mistaken grounds. I can see no injury which the property on that shore will sustain by having it barricaded against the inroads of the river, which every year carries off a portion of its alluvial bank. The contraction of the bed of the river will at the same time have the effect of removing the bar which now separates it from the steamboat channel and obstructs the passage to the market of Saint Louis, and will open to it all the advantages of the free navigation of the river. So far from injuring the ferry, it will eventually benefit it. During low water the ferry-boat has always been obliged to make a circuit above the head of Bloody Island Bar, and to move up her landing place on the Illinois shore to the foot of the *dry slough* and on the Missouri side to the mouth of Gengrass Creek. Should the bank of the river not form on to the pier a landing place can easily be made against it and a causeway to the shore. There will then be nothing to obstruct her passage at low water, and at high water she can pass over the pier with the same facility that she now does Bloody Island Bar. That the obstruction caused by this bar should be removed is not more for the interest of Saint Louis than it is for the general commerce of the river. Circumstances have made this city a depot for the exports and imports of the country above, and requires a reshipment in boats suitable for the navigation of the different rivers upon which they are to be transported. Whatever is done, therefore, to facilitate this commerce benefits those who are supplied as much as those who supply. The extensive country bordering on the Illinois River, the Upper Mississippi, the Missouri, and their tributaries is equally interested with the city of Saint Louis, and the State of Illinois will be as much benefited as the State of Missouri. Of the funds advanced by the city of Saint Louis, \$7,599.55 have been expended. A portion was applied to the repairs of the boats, &c., and the balance to the construction of the upper pier. There is besides this sum \$1,729.01 due on the contract entered into the first quarter of 1838 for the supply of piles. A part were furnished in 1838, and the remainder were to have been delivered this spring, but not required in consequence of the suspension of the work.

The facilities for continuing the work are the same as last year, and consists of a steam towboat, four transportation boats of 200 tons each, a pile-driver, laborers, quarters, a supply of drills, tools, &c.

Appropriations and expenditures.

In 1836 there were appropriated.....	\$15,000 00	
In 1837 there were appropriated.....	35,000 00	
In 1838 there were appropriated.....		
In 1839 there were appropriated.....		
		\$50,000 00
In 1837 there were expended.....	296 37	
In 1838 there were expended.....	45,471 68	
In 1839 there were expended.....	11,775 74	
		57,543 79

Estimate.

Total estimate.....	158,554 00
Already appropriated.....	50,000 00
Required for next year.....	108,554 00

All of which is respectfully submitted.

R. E. LEE,
Captain Engineers.

Col. JOS. G. TOTTEN,
Chief Engineer.

E.

EXTRACT FROM REPORT OF CAPTAIN ROBERT E. LEE, CORPS OF ENGINEERS.

SAINT LOUIS, 6th October, 1840.

SIR: * * * * *

2. THE ERECTION OF A PIER IN THE MISSISSIPPI NEAR SAINT LOUIS.

It was stated in my last annual report that the appropriation by Congress for this work had been entirely expended, together with a certain sum advanced by the city

of Saint Louis. No further appropriation having been made and the preservation of the boats and property being attended with expense, it became necessary to sell a part in order to preserve the other and to pay the arrearages already due. But from the injury and loss to which the boats were exposed, the repairs required to preserve them through the winter, the uncertainty of the time when they would be wanted and the expense of keeping them, it was considered more advantageous to dispose of the whole. They have been accordingly all sold and the funds placed to the credit of the appropriation.

The favorable operation of the work as far as constructed, which was described last year, still continues. The pier on the Illinois shore has served to throw the main body of the river west of Bloody Island, which has cut a broad and deep channel through the flat shoal that extended from the head of Bloody Island toward the Missouri shore. As this channel enlarges that east of the island diminishes, and between the pier and the head of Bloody Island is becoming more and more shoal.

The pier from the foot of Bloody Island confines the water to the Missouri shore and directs the current against the head of Duncan's Island. A large portion of the head and eastern face of this island has been washed away during the past year. The deep water now extends close to it and admits the largest boats to the lower part of the city. The depth of the river on the Illinois side is diminishing proportionally, and the shoal formed under the influence of the pier from the foot of Bloody Island is extending itself down the river and assisting the operation of the pier itself.

Both piers, however, require to be finished. The upper ought to be strengthened and extended down the river and the lower completed. The greater body of water that now passes west of Bloody Island is thrown by some cause from the rocky point above the city directly over toward Bloody Island, and has worn away the lateral shoal that extended from the island as far back as the line of the pier. The foundation of the pier where it crosses this shoal has consequently been undermined, but the settling of the stone to the bottom of the river has apparently arrested for the present the further action of the current. The shoal beyond the line of the pier has grown to an island and is covered with a growth of cottonwood trees. Its whole face now requires to be revetted with stone to prevent its further wear and the probability of the river breaking through and resuming its former channel. In this event the lower part of the pier, which was laid in deep water and remains permanent, would be separated from the upper part, and might connect itself with Duncan's Island and form a more permanent obstruction than has been removed. At present, the harbor is in a good condition, and only requires to be kept so. The only unfavorable circumstance that I can discover is the appearance of a small shoal near the foot of the lower pier, and about midway between it and the city. I believe it, however, to be an accumulation of sand washed from the shoal above, and that it is traveling down the river. I think it impossible for it to remain there under the present action of the current, and as far as I can judge it is diminishing.

The accompanying estimate is for the balance of the original estimate for the work, which is required to be appropriated for its completion.

All of which is respectfully submitted.

R. E. LEE,
Captain Engineers.

Col. JOS. G. TOTTEN,
Chief Engineer.

F.

EXTRACT FROM REPORT OF CAPT. T. J. CRAM, CORPS OF TOPOGRAPHICAL ENGINEERS

CINCINNATI, OHIO, *February 3, 1844.*

HARBOR OF SAINT LOUIS.

* * * * *

V.—OBJECTS TO BE ARRIVED AT, AND HOW TO BE ACCOMPLISHED.

What are the principal objects to be attained in works for the protection of Saint Louis Harbor?

The greater part of that portion of the city below Market street, as seen on the chart, has been deprived of its steamboat landing in low stages by the growth of the upper extremity of Duncan's Island. From the middle of the city all the way down past the United States arsenal there is now no steamboat landing at low-water stages. In 1830 the main channel was between the arsenal and a small island in front of it, and

in 1834 there was sufficient water in it, at the lowest stages, to admit of vessels coming to the arsenal landing. In February, 1834, Capt. John Symington, of the Ordnance Corps, then commanding at the arsenal, expressed his apprehensions in an official letter to the chief of his corps of the prospective destruction not only of the lower part of Saint Louis Harbor, but also of the arsenal landing.

The prediction of Captain Symington has been completely fulfilled, and that, too, in less than ten years from the date of his letter, so that now there is no low-water landing at the arsenal, nor any until we get up to opposite Market street, in the city of Saint Louis. The process described in 1834 by Captain Symington to be then going on in reference to the small island in front of the arsenal landing and tending to the destruction of the latter was essentially the same as that which is now going on in reference to the Saint Louis Harbor.

The principal landing is now above Market street, and extends to Cherry street, and from Cherry street quite up to the upper ferry landing there is a tolerably good low-water harbor.

In the present condition of things it may reasonably be said that any works projected and *executed* at the foot of Bloody Island, with a view to wash away the growing bar at the head of Duncan's Island, or to restore a low-water harbor to the lower part of the city or to the United States arsenal, would be unnecessary, so far as the general interests of commerce are concerned; nor would such works alone *preserve* the harbor, even supposing it possible to make them stand, for the obvious reason that they would have no effect upon the principal cause, as before explained, now operating in washing away the Illinois shore, and thereby tending to the diminution of the water in the channel next the city.

The lower part of the harbor may then be abandoned to its fate, and such ends aimed at as we can reasonably expect to accomplish, to wit: To *preserve*, as soon as possible, the portion of the harbor *above Market street*, taking especial care that all works that may be executed for this preservation shall not be put into the river in such positions as ultimately to cut off access to that which we are attempting to preserve.

As there can be no abrasion on the rock-bound city side, suppose we stop the abrasion on the Illinois side, in the reach B C. Is it not self-evident that, as long as the river runs in its present general channel, there must be found one channel, at least, through which steamers may approach the upper part of the harbor? And, even supposing, as a last resort, they should have to pass on the Illinois side around Bloody Island, it will certainly be better than to have no ingress or egress. But stop the abrasion of the Illinois shore, and insure a continuance of the same quantity of running water that now passes on the city side of Bloody Island, and there will be little danger of losing the steamboat channel between Bloody and Duncan's Islands. It is true, this channel might not always be as straight as would be desirable, but in all probability it would admit the passage of boats.

Hence, the object to be arrived at is, to force at least as much water as now passes in the west channel to *continue* to run there, and this by such works as will not cut off the access to the upper part of the harbor, supposing it as a last resort to become necessary to go round on the east side of Bloody Island to get ingress.

If the works should be executed which will be projected to attain this object, and should cause more water to pass into the city channel than now runs there (as in all probability they would), then the harbor will not only be preserved from further immediate injury, but it will be brought into a condition of becoming better and better every subsequent year.

* * * * *

All of which is respectfully submitted.

T. J. CRAM,
Captain of United States Topographical Engineers.

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G.

EXTRACT FROM REPORT OF CAPT. T. J. CRAM, CORPS OF TOPOGRAPHICAL ENGINEERS.

I.—CAUSES AFFECTING THE STABILITY OF THE WORKS.

Suppose the river at extreme low stage. Then the under-currents and consequent channels penetrate into the bed to their maximum depth. Down to this depth all is either in motion or easily put in motion by the slightest cause. At this depth conceive a surface having the line of its greatest declivity descending at the same rate of the river. All the material of the bed below this surface is stable.

This surface I denominate the surface of stability; and it is situated (in the extreme

low stage) at least 20 feet below that stage throughout the reaches B C, C D. Should a pile be driven into the stratum above the surface of stability without penetrating into the stratum below the surface, it would certainly be washed away, notwithstanding it be driven 20 feet into earth.

If works should be rested on the movable stratum as a foundation they would inevitably be washed away or sink to the surface of stability; and then, should they hold together, they would sink as much lower as would be determined by the degree of compressibility of the matter below that surface and the relative weight of the structure.

Suppose the river to rise from extreme low to extreme high stage. During the rise a vast quantity of silt comes down the river; and the velocity of the stream being modified at C, at I, and by the banks on both sides, and by Bloody and Duncan's Islands, down goes an immense deposit temporarily, and the bed of the river then in fact occupies a higher level than before, and the under-currents work in higher ground, and the surface of stability is also at a higher level.

These facts are well attested by the circumstance that in high stages of water boats do not find the increase of depth of the channel anything like the amount the river has risen in the mean time.

As the water subsides again to its lowest stage that which was so recently and readily deposited in the old under-channels, affording as a general rule less resistance than the older deposits immediately by, are the easiest to be cut out; but the recent deposits sometimes become so compact before the river begins to fall that the new under-channels are cut in a former deposit.

Here we have the cause of the creation of new bars and new under-channels in such variety every year in the bed of the river, and as this cause is one over which we can have no permanent control, it is idle to attempt by any works of art to prevent the formation of this class of bars and channels in the bed of the Mississippi.

Starting from an extreme low stage, as the river rises so does the surface of stability rise, and as the river again falls so will the surface of stability fall to its lowest position.

It is evident that all works intended for this harbor should be planned with reference to the lowest position of the surface of stability.

II.—CAUSES OF DANGER.

In a report of mine, 3d February, 1844, made to Lieutenant-Colonel Long, and by him transmitted to the Bureau of Topographical Engineers, and printed as Document No. 203, Twenty-eighth Congress, first session, House of Representatives, the dangers threatening the destruction of the Saint Louis Harbor are explained.

These dangers arise from actions going on in the portions of the river below the chain of rocks, also from the action going on at the junction of the Missouri and Mississippi.

After leaving the chain of rocks the current impinges against the Missouri bank in the vicinity of D, where great abrasion is going on; thence the force of the stream is deflected from that bank and takes a direction toward I on the Illinois bank, where great abrasion is also going on.

Whatever may have been the case in times gone by, it is certain the present natural tendency of the whole current is directly from D through C to I, and it is equally certain that no work of art of less power than the force of that current can arrest this tendency.

At C a division of the water occurs, a part running in the channel west of Bloody Island and forming the harbor of Saint Louis, the other portion running in the channel east of that island. In the report above referred to it is shown there are three temporary causes now acting to make more water run through the former than the latter channel. It is also shown that these three temporary causes will be progressively annihilated, if the abrasions at D and I be not arrested, and that the city channel will fill up and Saint Louis be deprived of its low-water harbor.

That these are the causes threatening the destruction of the harbor there can be but one opinion. In respect to the plans for arresting the evil, however, there is a diversity of opinion.

The conclusions I came to and recorded in said report of 3d February last are: "If we stop further abrasion at D and at I, we shall thereby preserve the harbor in as good condition as at present." "If we force more water to run in the minor channel on the east side of Cascarot Island, we shall thereby bring the harbor into a condition of gradual improvement."

Table of plans and their probable costs.

1.	2.	3.	4.	5.	6.	7.	8.
	Description of plan.	First cost, supposing surface of stability 20 feet below surface low water of June, 1837; also, that the summits of works, if put into the channel or water without resting against the banks, are to be 5 feet above that stage.	Addition to first cost, consequent upon the works sinking $\frac{1}{2}$ feet in virtue of contracting the area of the cross-section of the running prism of the Mississippi.	The minimum or least ultimate cost of each plan without elastic revetments described in my report of February 3, 1844, in detail.	Ratios of ultimate costs; the cost of No. 1 being the unit of comparison.	The maximum of greatest ultimate cost of each plan, stone revetments, described in my report, February 3, 1844, in detail.	Ratios of the ultimate maxima costs—cost of No. 1 being unity.
1	Two miles of dike, <i>a</i> ; 1 mile revetment on west bank Bloody Island; rebuild dike <i>b</i> ; a revival of the plan heretofore pursued by the United States and the city, with such additions and extensions as now seem necessary.....	\$228,577 00	\$84,573 00	\$313,150 00	1.000	\$372,022 00	1.000
2	Dam <i>d</i> , directly across Illinois channel at head of Bloody Island; revet 10,000 feet Illinois bank, from the dam upwards; revet 7,480 feet west bank Bloody Island ..	204,147 00	54,777 00	258,924 00	0.827	453,826 00	1.220
3	Dam <i>e</i> , directly across the Illinois channel at foot of Bloody Island; revet 18,840 feet Illinois bank, from dam upward; rebuild dike <i>b</i>	212,539 00	39,533 00	252,072 00	0.805	463,138 00	1.245
4	Three detached snags or tree-dams, <i>f</i> , <i>g</i> , <i>h</i> , $\frac{1}{2}$ mile long each, $\frac{1}{2}$ mile apart; revet 6,200 feet Missouri bank, in vicinity of D, revet 5,280 feet west bank Bloody Island; ultimately revet $\frac{1}{2}$ mile west bank of new deposits expected to be formed between the dams	200,972 00	61,490 00	262,462 00	0.838	425,162 00	1.143
5	Canal X, through Gingrass Creek bottom; revet 6,300 feet of Missouri bank, in vicinity of D, also 8,400 feet Illinois bank, in vicinity of I	513,461 00	-----	513,461 00	1.639	677,366 00	1.822
6	Revet 6,300 feet Missouri bank, in vicinity of D; revet 8,400 feet Illinois bank, in vicinity of I; pier at chain of rocks, 3,500 feet long, to force more water on east side Cascarot Island into city channel.....	195,230 00	27,245 00	222,475 00	0.714	386,380 00	1.038

Having again examined the banks and currents and bed and the effects of this summer's flood since the waters began to subside, and having discovered no circumstance to induce different conclusions, but having observed effects decidedly favorable to the efficacy of the works I suggested in that report, I now iterate the opinion that the harbor may be preserved from the danger due to causes having their locality below the chain by stopping further abrasion in the vicinity of D; stopping further abrasion in the vicinity of I; causing more water to run in the channel east of Cascarat Island.

III.—ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES OF THE SIX PLANS IN THE TABLE.

The area of both cross-sections is 41,312 square feet (at the stage in October, 1843, when my survey was made). The ratio of the section of the city channel to the section of the Illinois channel is as 1 to 0.636.

Areas somewhat different from these will be found by making the sections at different places; also would the areas be different in lower stages. But if we take the mean of the ratios of the areas of the sections of the two channels at the low stages, we shall find this mean ratio of the area of the section of the city channel to that of the Illinois channel as 1 is to 0.625 (in October, 1843).

Representing the area of the city channel by A_c and that of the Illinois channel by A_i , and we shall have the following mean results applicable to low stages:

$$\begin{aligned} & \dots A_c : A_i :: 1 : 0.625. & (1) \\ & \dots A_c + A_i : A_c :: 1 : 0.615. & (2) \\ & \dots A_c + A_i : A_i :: 1 : 0.385. & (3) \end{aligned}$$

Now, suppose we adopt either of the plans 1, 2, 3, 4, building the works to a level of 5 feet above extreme low stage of June, 1837, the surface of stability being supposed 20 feet below that stage, all the water of the river running in the reach BC in all stages below the summits of the works would pass through the city channel.

The first effect that would ensue would be an increase of the velocity in this channel. Let v represent the present mean velocity, v' the increased velocity.

From proportion (2) we have

$$v : v' :: \frac{1}{A_c + A_i} : \frac{1}{A_c} :: \frac{1}{1} : \frac{1}{0.615}; \text{ whence } v' = 1.626 \times v;$$

so that if the present mean velocity be 4 miles the hour, the increased velocity would be $6\frac{1}{2}$ miles the hour.

The next effect would consist in an abrasion of the bed of the city channel in consequence of the increased velocity; the abrasion would go on progressively until the mean area of the cross-section would be enlarged so as to become equal to $A_c + A_i$; when the mean velocity of the channel would again be reduced to v , or its present rate; then the abrasion would cease.

While the city channel would be thus deepening, the works constructed contiguously thereto would be sinking, the surface of stability being lowered in proportion as the deepening would go on. The amount of sinking will now be estimated.

The mean depth of the cross section of the water in the city channel in low stages may be estimated at 14 feet. Let d represent the increment of the depth due to the abrasion consequent upon passing the whole running prism of the Mississippi through the city channel confined to its width in October, 1843. We shall have the ultimate value of d expressed by $d \times 1721 = 16071$; from which

$$d = \frac{16071}{1721} = 9\frac{1}{2} \text{ feet.}$$

Hence the mean depth of the city channel would become $14 + 9\frac{1}{2}$ or $23\frac{1}{2}$ feet by the time the river would again acquire its permanent motion.

The amount of the sinking of the works would therefore be $9\frac{1}{2}$ feet, a result that if practically verified in the present condition of the works heretofore constructed in the harbor, which are shown by the soundings taken over their summits in October, 1843, to have sunk in places from 5 to 10, and even 15, feet below their original level within a period of less than five years.

In the estimate of the costs of the various plans, therefore, it will be necessary to include an item to cover the expense of building up the works again after settling to a depth of $9\frac{1}{2}$ feet lower than their first position. This additional item is expressed in column 4 of the table.

The quantity abraded from the bed of the city channel would be sufficient to cover an area of $1\frac{1}{10}$ miles in length, $\frac{1}{2}$ mile in breadth, to a depth of $9\frac{1}{2}$ feet. This matter would be translated from its present position and deposited in the reach of the river next below B C, and there it would very probably form an island or several islets, rendering the navigation intricate, to say the least.

The circumstances that might be expected in reference to this new deposit are such as exist at the foot of the "Grand Chain," about 160 miles below Saint Louis, where,

from the channel over the rocks being narrow, an increase of velocity is created, and the water on leaving the chain, escaping with this increased velocity, has swept out the bed of the Mississippi below the rocky channel for an extent of two miles to a depth of ten feet more than the usual low-water depth in other parts of the river. And the several islands formed in the reach of the river next below give rise to various channels, which are all difficult of navigation in low stages. (See my report made through Lieutenant-Colonel Long to the bureau on the "Grand and Little Chains," in June last.)

Hence there is involved in 1, 2, 3, 4, a contingency which offers a serious objection to either of these plans. It is that the new deposite of islets and consequent channels in the reach below B C might be such that for some days, while the river would be falling, an ascending steamer could neither pass through into the lower part of the harbor nor pass over the tops of the works of these four plans so as to enter the upper part of the harbor by running around on the east side of Bloody Island, and thus all the boats ascending to, or ready to descend the river from, the harbor would be virtually stopped until the low-water channels among said islets should be cut to a depth sufficient for the passage. The detention, however, would probably continue for only a few days.

Plans 1, 2, 3, 4 contemplate cutting off a portion of Illinois from the natural navigation of the Mississippi. There is an injunction from the courts of Illinois still in force prohibiting further work from being done on dike *a* that was commenced by the city.

The jurisdiction of the State of Missouri not extending to the Illinois bank is a circumstance that should be taken into account in the plan that is to be adopted. Any plan depriving the owners of the soil on that bank of the natural advantages of their channel would on that account be objectionable, and if executed would give rise to claims against the United States for damages.

Plans 1, 2, 3, 4 would, either of them, materially injure, if not wholly destroy, the upper or lower ferry, or perhaps both, now communicating between the city and the Illinois side, and at no distant day the ferry landings on that side would be so remote Saint Louis would feel the necessity of restoring communication by the construction of a very expensive bridge.

Plans 1, 2, 3, 4 would be liable to damages from ice and drift-wood, and the annual repairs would be very great.

The characteristic of plans 5 and 6, it will be perceived, consists in not diminishing the area of cross-section of the water running in the Mississippi, and therefore none of the objections consequent upon a diminution of the section (as in plans 1, 2, 3, 4) can be urged against 5 and 6.

Plan 5 has its objection, consisting in being liable to a destruction of the banks of the canal *x*, and in the probable necessity of being ultimately obliged torevet D and I, which would swell the ultimate cost of this plan to the sum seen in the table, and the expense of tending the guard-gates at the head of the canal, and besides, in so far as throwing more water through the city channel is the object, the canal *x* would be no better than the natural channel on the east of Cascarat Island.

Plan 6 has the objection that if any change should occur, as may possibly be the case, to cause the line of direction of the force of the current in the reach C D to attack the bank higher up than at present, we should have to continue the revetment further up the river, which would make this plan cost ultimately more than is expressed in the table. Also, more water being forced by the proposed pier at the Chain of Rocks to run in the channel east side of Cascarat Island might abrade the Illinois bank opposite this island, and we might ultimately have torevet there; or it might abrade the bottom of this minor channel and produce additional deposits below C or in the neighborhood of that point; but it will be perceived these effects would not prevent the water through this channel from accomplishing its office of throwing more water into the city channel, and it is probable the additional deposit would not be in sufficient quantity nor have such a position as to impair the navigation materially. It may be thought the revetments (such as explained in my report of February last) would be liable to injury from ice. I admit this. Still it is believed they would be no more liable to this kind of damage than the best of the other plans; and it is certain the elastic wooden revetments pertaining to plan 6 would be far more easy to repair than the works pertaining to either 1, 2, 3, 4.

The objections that have been pointed out as applicable to plans 1, 2, 3, 4, and 5 do not apply to 6, and therefore this plan 6 of revetting at D, at I, and constructing the pier at the chain has more advantages to recommend it than either of the others.

Respectfully submitted, August 20, 1844, by

T. J. CRAM,
Captain Topographical Engineers,
Superintendent Public Works, Harbor of Saint Louis.

J. J. ABERT,
Colonel Topographical Engineers.

H.

EXTRACT FROM REPORT OF LIEUT. COL. S. H. LONG, CORPS OF TOPOGRAPHICAL ENGINEERS.

OFFICE WESTERN RIVERS IMPROVEMENTS,
Louisville, Ky., Nov. 7, 1844.

SIR: As a member of the board appointed "to revise the plans and estimates which have been submitted by Captain Cram for the improvement of the harbor of Saint Louis, and for the protection of the Illinois shore against the action of the Missouri near its mouth," I have the honor to submit my views and opinions in brief as follows:

1st. The main object of all the plans referred to appears to be the improvement and preservation of the harbor of Saint Louis, and of course the several plans (six in number) are to be considered with a special reference to the attainment of this object.

2d. All plans devised for this purpose by Captain Cram and others have a common reference to, and are intended to promote, the enlargement of the volume of water passing through the harbor or between the Saint Louis shore and Bloody Island, and a corresponding reduction of the volume passing between the same island and the Illinois shore, together with such a modification of the currents of the former volume as will throw them as nearly as practicable into a parallelism with the Saint Louis shore.

3d. Captain Cram in his reports of February, 1844, and of August 20 of the same year, signifies his decided preference for Plan No. 6, as described and estimated for in his report of August, 1844. In this view I unhesitatingly agree with Captain Cram in many respects, while at the same time I would qualify my concurrence in sundry particulars hereinafter to be noticed.

4th. Plan No. 6 contemplates 1st. The construction of a dike or jetty at a rocky point in the west bank of the Mississippi, a little above the head of Cascarat Island, called the chain. 2d. The construction of a revetment 6,300 feet long on the Missouri shore in Sawyer's Bend, about four miles below the chain. 3d. A revetment 8,400 feet long on the Illinois shore opposite to Saint Louis and about five miles below the head of Sawyer's Bend. 4th. A revetment of undefined extent on the west side of Bloody Island and contiguous to the harbor of Saint Louis. 5th. A revetment similar to the last-mentioned on the Illinois shore opposite to Cascarat Island, the adoption of the last two items being contingent on the effects produced by the other constructions on and after their completion.

7th. Of the items previously mentioned in numerical order, the first, which contemplates the construction of a dike at the chain, is undoubtedly a work of prime importance, and ought to be commenced and prosecuted with energy and dispatch on such a scale and to such extent from the shore toward the head of the slough on the east of Cascarat Island as may be found adequate to the diversion of such portion of the water from the west to the east side of the island as is requisite to the formation of a navigable channel on the east side of the island.

8th. Preliminary to and in connection with this part of the works a careful survey, accompanied by soundings, borings, &c., should be made of a sand or gravel bar of long continuance, which bar commences near the Illinois shore opposite to the chain, and extends obliquely downward toward the Missouri shore, having a tendency to divert the water from the slough east of Cascarat Island, which but for the bar is obviously the channel best adapted to the reception and transmission of the main volume of the river in its downward course. If this bar should prove to be composed of sand or other loose materials of a character to be abraded and washed away by the ordinary current of the river, its removal may be effected by the action of the increased volume of water thrown across it by the construction of the proposed dike at the chain; but in the event of its being composed of compact and unyielding materials, which is probably the case, an artificial channel at least 200 feet wide and $4\frac{1}{2}$ feet deep, as measured downward from the surface of extreme low water, should be formed across the bar by dredging or by some other mode of excavation.

9th. By the means above considered the flow of water on the east side of Cascarat Island will be greatly increased, while that on the west side or through Sawyer's Bend will be diminished in an equal degree. Thus modified the two volumes, passing on opposite sides of the island, will unite, as heretofore, at a point a little below the foot of the island; but the volume on the east of the island being enlarged, and that on the west diminished, the resultant currents will be deflected more to the right than they are at present and will have a greater tendency to flow through the Saint Louis channel or harbor as contemplated in paragraph 2.

10th. The revetment on the Missouri shore, in Sawyer's Bend, is deemed inexpedient and unnecessary for the following reasons: First, in the event that abrasions still continue to be made as heretofore, they will in all likelihood be arrested at a short distance inland from the places where they now occur by a rocky-bound shore, situated at the base of the river hills; second, the abrasions will be greatly diminished, if not

prevented, by reducing the flow of water through Sawyer's Bend; and, third, the resultant of the two currents below their junction, at the foot of Cascarat Island, may be made to assume a proper direction through the Saint Louis harbor by enlarging the channel across the bar as contemplated in the eighth paragraph, or by prolonging the dike contemplated in the seventh paragraph, or by both of these means combined.

11th. The construction of the revetment on the Illinois shore, opposite to Saint Louis, may be regarded as contingent on the effects produced by the dike and channel contemplated in paragraph seventh and eighth. In the event that such a structure should ever be called for, which is not unlikely to prove true, it is fairly questionable whether a bed of snags or a series of snag-dams, securely anchored and weighed down with stones and gravel, constructed on the extensive sand-bar that occurs between the head of Bloody Island and the upper ferry-landing on Kerr's Island, may not advantageously be substituted instead of the revetment. As before stated in reference to Sawyer's Bend (paragraph tenth), the volume flowing through the Illinois channel being reduced, the tendency to abrasions on the Illinois shore will also be diminished.

12th. A revetment of greater or less extent along the west side of Bloody Island is likely to be required, not only for the preservation of the island, but as a means of giving to the currents through the Saint Louis channel or harbor their proper course and direction. A revetment like that proposed by Captain Cram is deemed appropriate for these purposes.

13th. A revetment of greater or less extent on the Illinois shore opposite the Cascarat Island, similar to that treated of in the preceding paragraph, will probably be required in order to prevent abrasions of the shore at that locality which will be likely to take effect on the completion of the dike and channel treated of in paragraphs 7 and 8. The location and construction of this part of the works should also be contingent on the results produced by the dam and channel.

14th. A similar revetment may also be required on the east side of Cascarat Island, near its foot, to prevent abrasions on that part of the island, and also to prevent the currents that flow to the right and left of the island from uniting at a point higher up than that at which they now coalesce.

15th. Having thus considered the several works contemplated in connection with plan No. 6, as proposed by Captain Cram, together with several topics of much importance in reference thereto, I deem it pertinent to subjoin my opinion as to the order in which the works should be prosecuted, and the probable cost of the same.

16th. The dike at the chain being regarded as necessary under any and all circumstances, its formation may be commenced with the least practicable delay. While the dike is in progress, and in the event that the opening of a channel across the bar at the head of the slough in the left of Cascarat Island should require mechanical force, I would advise the prosecution of this part of the work *part passu* with that of the dike. These works should be completed, or nearly so, during the year 1845.

17th. Having waited for the subsidence of the ensuing spring-freshets (viz, the freshet of 1846), and carefully observed the changes and other effects produced by the works just mentioned, I am inclined to think that of the residue of the works, the first to claim attention will be the formation of a bed of snags or a series of snag-dams between the head of Bloody Island and the upper ferry-landing, a little above the foot of Kerr's Island. Subsequently, the revetment on the west side of Bloody Island, the revetment on the east of Cascarat Island and that on the Illinois shore opposite to Cascarat Island may probably, and with propriety, be undertaken and executed in the order in which they are here mentioned.

18th. The cost of the dike, exclusive of that of the boats and other apparatus required for its construction, surveys, superintendence, &c., included, may be estimated at about, say.....	\$85, 100
One steam towboat.....	10, 000
Four stone-flats or decked scows, at \$600 each.....	2, 400
One steam pile-driver or engine.....	2, 500
One dredging-boat to be worked by steam.....	6, 000
Four dirt-scows or dredge-flats, at \$250 each.....	1, 000
Probable cost of opening channel across gravel-bar, exclusive of boats and other apparatus, say.....	8, 000
Amount required.....	115, 000
Deduct appropriation for 1844.....	25, 000
Amount required for 1845.....	90, 000

Respectfully submitted.

S. H. LONG,
Lieut. Col. Topographical Engineers

Col. J. J. ABERT,
Chief of Topographical Engineers.

I.

EXTRACT FROM REPORT OF LIEUT. COL. JAMES KEARNEY, CORPS OF TOPOGRAPHICAL ENGINEERS.

WASHINGTON CITY, *March 1, 1845.*

SIR: Your orders of the 1st of October, directing Lieutenant-Colonel Long and myself to meet at Saint Louis to revise the plans and estimates of Captain Cram for the improvement of the harbor of Saint Louis and the protection of the Illinois shore against the action of the Missouri near its mouth, were duly received; and it having been decided, after we had viewed the ground and conferred together respecting the plans, that each officer should present his separate report upon the subject referred to us, I have now the honor to forward the one prepared by Lieutenant-Colonel Long, and at the same time to report, on my own part, as follows:

The points of consideration are: First, the improvement of the harbor of Saint Louis, and, second, the protection of the Illinois shore against the action of the Missouri near its mouth; and these are sometimes viewed as inseparable, because it is believed that the action of the river upon the Illinois shore very probably influences the direction of the currents and the channels as low down as Saint Louis. It is even feared that unless this bank is defended the river may not only break through it into the valley of Long Lake and pursue that line at the times of freshets, but that ultimately it may even abandon its present *low-water* channel for that route.

Participating generally in these views, and yet differing from them in at least one very material point, I will have to give some reason for so doing when I come to describe the causes which, in my opinion, are operating to the prejudice of the harbor; and I think it will assist us in understanding them if we first take a cursory view of the river from the vicinity of Alton, toward which the freshets of the Missouri often ascend, and near which, in adding its volume to that of the Mississippi, it impresses upon it its own character. Beginning, then, near this point, and following the river to Saint Louis or to some short distance below, we find, with but two exceptions on the west, where rock appears, that both banks of the river are alluvial and unstable to an unknown depth, as are also the islands which divide the stream and the channels and shoals. To the same point at which we commenced this survey, ascends on the east the valley of Long Lake (part of the American Bottom), which is separated from the Mississippi at one place by a narrow bank of only 400 yards, and against which the freshets of the Missouri flow with very destructive force. The intervening bank here rises to its general level, some 30 feet above the lowest stage of the river, and 8½ feet above the highest-known freshets prior to the last, which exceeded it by 10 feet.

The main current of the river having impinged upon the left bank at the point of confluence of the two rivers, thence follows that bank until, arriving near the head of Choteau's Island, it is deflected toward the right bank, which it reaches near the "Chain of Rocks," some nine miles above Saint Louis and seven or eight below the mouth of the Missouri. Flowing along the front of the "Chain" in the direction of the branch of the river east of Cascarot Island, it might be expected, agreeably to all analogy, to force a passage at all stages of the river into that branch and to wear a deep channel there. Nevertheless, it turns abruptly around the southeastern point of the Chain to the right, and thence follows the concave line of Sawyer's Bend, west of Cascarot Island, until it arrives at the narrow passage between Bissel's Point and Kerr's Island.

Near the head of the branch of the river which flows east of Cascarot Island, or some short distance above, there is, as I learn from the pilots, a hard, gravelly bar, extending across the head of that branch, and nearly dry at low-water, and hence, doubtless, one of the reasons for the anomalous direction of the deep channel around the point of the Chain of Rocks. The eastern arm of the river is not now navigable by steamboats at low-water, but the current which flows by that route has, nevertheless, an important influence upon the position of the channel between Kerr's Island and Bissel's Point, as is shown by Capt. R. E. Lee's map of his survey of 1837, at a period when the river was 12 feet above its lowest stage. I refer to this map alone, as I have not Captain Cram's, made at a lower stage, before me.

We see from the form of the shores, as delineated on the map to which I refer, and from the soundings in Sawyer's Bend, at least when the river was 12 feet above its lowest stage, that but for some influence foreign to it the current on leaving the bend should cross the river obliquely toward Kerr's Island, and cut its deep channel on the left of the narrows rather than upon the right, where Captain Lee places it. Its actual position at this stage of the river must doubtless be ascribed to the sole influence of the body of water which comes through the Cascarot Island passage, an influence which not improbably exerts itself with greater comparative energy in the higher stages of the river, because it is only when the freshets have risen some feet above low-water that it can pass very freely to the eastward of the island.

At Bissel's Point the river does not exceed 1,450 feet in width. It then spreads itself very rapidly to about three times that width, and this it holds to the head of Bloody Island, some 6,100 feet below the point. In front of Saint Louis it is divided by the island, the two branches together having about twice the width of the river at Bissel's Point. The left shore, below the narrows, is slightly concave, and it lies very nearly in line with the lower part of Sawyer's Bend, but with the curve reversed, as it is on the opposite side of the river. On the right the shore turns suddenly from Bissel's Point toward the west, and near Gingrass Creek (Pingrass of Captain Lee's map) it again turns abruptly, but in an opposite direction, and makes a deep re-entering angle toward the river, the angle being between Gingrass Creek and Rocky Branch. Above the angle the banks are alluvial; below, the shore is formed of limestone in place. It is at this angle or bend of the western shore that the river attains its greatest width.

The floods, on issuing from the narrow passage abreast of Bissel's Point, diffuse themselves necessarily over the broad surface I have described, but at some seasons certainly with the greater force toward the west, by reason of the impulse they receive from the current coming by the eastern channel around Cascarot Island; and this volume of water flowing toward Rocky Branch must strike the shore below that branch with some abruptness, at an angle nearly of 40° , and hence we may suppose that it is repelled toward the Illinois shore and toward the head of Bloody Island. A considerable portion of it, nevertheless, escapes along the western shore and follows the city channel. That the shore below Rocky Branch must have the effect to force part of the stream toward the east I think is very manifest from the position which that shore occupies with respect to it. Now, the velocity of the rejected portion being necessarily diminished along its line of junction with that part of the main body of the river which follows directly the movement of the Illinois branch of the current, it there deposits large quantities of the sedimentary matter with which it is charged, and forms shoals that every year continue to advance up stream toward Gingrass Creek; and it is apprehended that these shoals may ultimately extend without interruption quite across the western channel and destroy at least the low-water navigation of the Saint Louis side of the island.*

The current from Rocky Branch Bend, which escapes by the western channel, does not flow in contact with the city shore along its whole front. It is deflected toward Bloody Island, the western shore of which it sweeps as it descends toward its southern end, and hence it may be seen that the lower end of the island is exposed occasionally to the attack of the current, while the head lies more under the protection of the eddies and within the area of the sedimentary deposits which are extending themselves into the bend. It may be expected, therefore, that, as the low-water channel closes on this side of the river, the island will continue to follow the extension of the shoals upstream, so that ultimately there may be found between it and the Missouri shore little more than a low-water slough, and if we descend to that part of the river near which the two branches of the stream reunite, viz, near the foot of Bloody Island, and examine that locality we will find further reason for apprehending this result. We will there see that, at least under some conditions of the freshets, the force of the eastern or Illinois current already so far predominates over that on the Missouri side as to encourage the deposit of detrital matter within the entrance of the city channel, while it maintains its own very superior and sufficient depth close under the Illinois shore to an indefinite distance below Cahokia Creek. In fact, we sometimes find the deposits in front of the city to be already so extensive as to excite serious uneasiness as to the future, while the actual present impediment to the navigation is of no small magnitude.

But it is not only the form of the shores and the variable breadth and the extreme mobility of the bed of the river that affect the stability of the channels. The extreme variability of the volume of the stream contributes largely to the changes to which the river is constantly subjected, and especially is this the case near the city. We know that the force with which the current strikes the shores is proportional to the squares of the velocities and of the sines of the angles of incidence and that the reaction must observe the same law in a contrary direction, and hence, if we are correctly informed respecting the velocity of the currents of the high and low stages of the river near Saint Louis, the force with which they are repelled by the rocky shore above the city and their tendency toward the Illinois side is at some stages of the river nearly twenty times as great as others, and hence we may see the probability that while, at ordinary or low stages, the main current may now be found upon the city side of Bloody Island, yet that during the higher freshets it may follow the eastern side, and moreover that the increased volume and velocity on this same eastern side may so far preponderate as they descend below the island as very essentially to

*The accompanying diagram will show the influence which I suppose the shore below Gingrass Creek exerts upon the stream in its tendency eastward, or the general principle upon which it is based. The lines actually traced by the direct and reflected filaments $a a' b b'$ are not in fact right lines, for, their form is very essentially modified in approach, and receding from the deflecting plane $c c'$ toward the resultant or resultants of the forces in motion. The lines of $b b'$, &c., indicate merely the direction of the force at the moment of deflection.

assist in diminishing the western current, and thus augment the deposits of sedimentary matter toward the foot as well as at the head of the island on that side, and that thus the bed of the river in that arm may be quite sensibly elevated during the higher freshets. It is likewise very probable, owing to the extreme mobility of these deposits, that the force of the ordinary currents of the river on its return to its usual channel may be quite capable of reopening those channels, if not upon their whole area at least upon some portions of it. This speculation, it should be observed, is quite consistent with the received laws of motion of rivers, with the facts shown on Captain Lee's map, already referred to, and with the observations reported by the river pilots.

I may add that the quantity of sediment brought into the usual low-water navigable channel at any one time may be so great and its bottom may be so much raised by it as to reduce the depth and consequent force of the stream, so that upon its resuming its usual line of movement its abrading force may prove to be less than the resistance of the bottom. In this case the main current will have abandoned its ancient bed for the new line traced for it by the freshets.

Now, if what I have said respecting the expansion of the river and the form of the shores below Bissel's Point and their influence upon the general movement of the stream be well founded, it is very certain that some works will be required below that point for the purpose of regulating the currents, whatever may be the state of the river or the direction of the principal velocities above it; and it is likewise certain that these works should be calculated to give to the current on the western side of Bloody Island a decided preponderance, as it respects volume and velocity, over that of the Illinois side.

The favorable effect of the works would doubtless be very much promoted if the main current of the river followed at all stages the western bank under Bissel's Point, or where we find it on Captain Lee's map, rather than the eastern, because in the former position it would have a direction toward the city of Saint Louis, or the one would ultimately wish to impress upon it; for, supposing this to be its permanent position under the influence of Cascaret Island or eastern current above Bissel's Point, and that the shores above the city were parallel, or nearly parallel, with this direction of the stream, I can see no reason why the main channel should manifest a disposition, as now evidently it does, to abandon that for the opposite side of the river, assuming, as I think we fairly may in this case, that the inclination of the river exerts but little influence upon this tendency. But it is likewise quite apparent, I think, that if the maximum velocity were found upon the eastern or Kerr's Island side, as the stream issues from the narrows, or in the position resulting from the sole influence of the current of Sawyer's Bend, then, owing to the form of the banks on that side, it should necessarily continue to flow along the Illinois shore, for it would find no deflecting surface to oppose its course along that line. Now, if upon examination it be found, as very possibly may be the case, that the current already has, at the lowest stages of the river, the direction best calculated to throw the channel on the city side, and as I have said that it is only after leaving the narrows it is turned from this line of direction, then it follows, I think, that our principal works should be located below the narrows, and it is even no less clearly my opinion that our operations ought to be begun there, although on a full examination of the facts we may find that the current does flow sometimes more strongly toward the one side and sometimes toward the other, in consequence of the variable force of the currents which arrive from the two branches of the river at Cascaret Island. In fact, the reason for regulating the course of the stream below Bissel's Point by means of works below it is quite as strong in the one case as in the other.

Under any view we may take of the subject, and whatever the plans we contemplate, our intention must be, certainly, to add such a volume of water to the western side of the river as will insure to the channel there a sufficient depth at extreme low water for all the purposes of navigation; and we may be sure that we can command quite enough for this purpose if we turn the whole of the low-water stream to that side of Bloody Island. In proof of this we have only to refer to the maps and reports in possession of the bureau. Now, in my opinion, the existence of a channel on each side of the river for the general purposes of commerce is clearly an impracticability, and therefore, if the interests of commerce impose the obligation of preserving one of them, the extinction of the other must, in my opinion, follow as a necessary consequence of the measure, calculated to fulfill this obligation, as these measures must contemplate the closing of the abandoned arm of the river in order to secure a sufficient volume of water to the other at all stages. For this purpose a dam to extend from the Illinois shore to Bloody Island will be required.

If our purpose were merely to bar this branch of the river, the best and most economical position for the dam would be found some distance below the head of the island, because in this position we would have the shortest line and we would have also the inertia of a body of still water interposed between the work and the main current, and we might reasonably expect therefore that the work would not sink below the plane

equilibrium resulting from the weight of the structure and the compressibility of the soil on which it was founded.

On the contrary if we are constrained by the conditions of the problem, as I think we are, to place its foundations within reach of the current, the foundations must follow the erosive actions of the stream and descend at least to the bottom of the excavation which this will be likely to form at the base of the structure. The depth to which the work may be carried by reason of the action of the current upon the bottom of the river cannot now be estimated with much precision, although we are in some measure guided in our inquiry respecting it by the effects we see produced upon the bottom wherever the current strikes the shores obliquely.

Supposing, then, that it is determined to erect the dam in a position exposed to the action of the current, its inclination with respect to that current ought to be such as to enable it to receive the stream under the most favorable angle for transmitting it in the direction we would prefer to establish the line of the channel in, because, owing to the extreme mobility of the bed of the river, it is to be apprehended that if great attention is not given to this point, and if the current should meet the obstructions at a high angle, or very abruptly, it would have the effect to turn the whole volume of the river, and therefore the main channel, into the deep bend near Rocky Branch, at the manifest risk of establishing a rapid current under the western side of Bloody Island, especially toward its lower extremity, in consequence of the new direction which it would probably receive from the shores immediately below Rocky Branch. This line of direction, I think, ought to be guarded against as much as possible, because not only it would endanger the existence of the lower part of the island, but, what is of yet more consequence, it might result in the fixing of the so called "traveling bars" abreast of the lower parts of the city and in the prolongation up-stream of the head of Duncan's Island. I think that to guard against these results the channel should be made to follow in a line whose general direction would be somewhat parallel with and not very remote from the line of Captain Lee's dam, and for this purpose the work itself need not be located very far from his position, namely, between the lower end of Kerr's and the head of Bloody Island. The exact form which it should have in the horizontal plane, in order to adapt it to the purpose of transmitting the currents most advantageously, will be, doubtless, a subject of very careful investigation when the department will have before it all the facts bearing upon the question. Meanwhile I may say that I do not suppose that if it were traced upon a straight line between the points I have mentioned it would be so likely to give the channel the position we would wish as if it had the form of a curve, having its concave side toward the current, because in the case of a curved dam, concave toward the stream, we can modify the angle under which it should receive the shock of the stream at every point so as to deflect it in conformity with the line we might wish it to follow in its progress. Thus, it appears to me, a dam of this form might be traced upon a line which would guide into the city channel the current which now flows eastwardly. The lower extremity of the work should rest upon and coincide with the upper portion of Bloody Island, the western shore of which ought then to be revetted in prolongation of the curve at least down to the triangulation point B' of Captain Lee's map. It should also unite by a similar revetment with Kerr's Island.

It will be seen, on inspecting the map, that a current following the guidance of such a line might be made to unite with the more westwardly current somewhere near Station XXIV, so that the resultant of the two currents should be found more decidedly upon the city side of this arm of the river, and we might reasonably expect that their aggregate effect would be felt much lower down the commercial front of the city than the point at which the channel now touches it. If this were the case, then, doubtless, also we would have reason to expect that the lower end of Bloody Island would rapidly extend itself down-stream and that the channel might follow for some distance the line of the eastern or northeastern shore of Duncan's Island, and very possibly at the expense of at least a considerable portion of that island; and I need scarcely add that this could not be very advantageous both to the commercial part of the city and to the navigation of the river.

The height to which the top of the dam ought to be raised is, I think, a question important enough to authorize a few words respecting it in this place. Its object is to obstruct the passage of the current into the eastern arm of the river when the waters are so low as to lead us to apprehend a deficiency in the western channel. Besides this its object is to direct the stream towards the city. It is needless, therefore, to raise the work higher than may be found necessary for these purposes, and its height will depend, therefore, upon the stage of the river capable of supplying water enough for the maintenance of the navigation on the western side of the island. I suppose a depth of 4 or 5 feet quite sufficient for a low-water channel here, and if this be so, or if even a greater depth is desirable, I see no reason to doubt, as I have already said, that the sufficiency of the volume of water at the most extreme low stage of the river, for in front of Bissel's Point where the river is some 30 or 40 yards wider than the passage west of Bloody Island, we see how very deep the channel is, and that it is only necessary to compel

the current to observe some well-defined and permanent line of movement. We may be certain also that in the case of a river whose bed is composed of such light and incoherent matter as the Mississippi the increased depth resulting from the increase of the volume of water will be chiefly due to the excavating power of the stream and that there will be but little of that increased depth attributable to the elevation of the surface of the river in the improved arm, above its original height. I presume, for these reasons, that the top of the dam need not be raised much above the highest point of the surface of the western side of the river at low-water, that is to say, the top of the dam need not be more than high enough to direct the whole volume of the river at such times upon its new line of movement.

If the dam were placed some distance below the head of the island it is probable that owing to the declivity of the stream we would find that an elevation of some feet might be required to correspond with the declivity which the river ought to have in the contrary direction. Or if, on the other hand, we were to construct the dam near Captain Lee's line upon a curve concave to the stream for the purpose of giving the current the most suitable angle of deflection, then owing to the centrifugal force there would be some elevation of the surface near the dam but none to exceed a few inches. I think it probable, therefore, that in no case need the top be elevated more than one or two feet if the work occupies the position referred to in the first hypothesis or ten or twelve inches in the second—the plane of comparison being the surface of the river at extreme low water. We thus find that it may be kept so low as to pass the ice and other floating bodies with but little danger of injuring the works; for I apprehend that these are rarely brought down the river in any serious quantities until the freshets have risen several feet above the height I have mentioned.

Keeping the dam thus low, we likewise relieve it from the force of a dangerous overfall upon the down-stream side and we practice a double economy of materials, as it respects the quantity saved in the height of the structure and in the breadth of the apron, which in all cases must bear some proportion to the height of the fall.

From what I have said respecting the influence of the western shore of the river upon the direction of the current below Bissel's Point and the object, also, of the proposed works between the two islands, namely, the absolute exclusion of the stream from that side of the river at the period of low water, you will see that I do not entertain the opinion that openings should be left in the dam for purposes of navigation. In fact, they would be followed, as I believe, by very pernicious consequences, inasmuch as the foundations near each opening would present two weak points of attack, and that, too, where the current must necessarily have acquired a considerable accession of force. There would be doubtless a deepening of the bed of the river at these points, but there would be eddies formed below them, and these would probably have the beneficial effect of assisting in the silting up very rapidly of that arm of the river, for I do not suppose that all the currents flowing through the openings would maintain separate lines of movement for any very great distance below the dam, but that they would be likely to reunite not long after they had passed it, and I think it may be reasonably assumed that between the dam and the points of reunion there would be a material diminution of velocity and necessarily a deposit within that space of much of the sedimentary matter carried forward by the current. Hence I see only the objection to these openings that they could not preserve the existing navigation through the eastern arm of the river, and that they would have the effect to assist very extensively in undermining the foundations of the work.

At the moment of describing the extent to which the revetment of the west side of Bloody Island should be carried in connection with the proposed dam, I omitted to say that very possibly the enlargement of the volume of the river on that side at ordinary and low stages might have the effect to cause it to widen its bed in obedience to the known tendency of streams unless the banks were defended against the lateral action of the current, and that therefore it is not improbable that a further extension of the revetment towards the foot of the island may become necessary. I may also add, in connection with this item of expense, that in the first instance some excavation may be required along the proposed line of channel parallel with the dam, in order to insure to it its proper direction, and in doing so I will have completed the enumeration of the works which, in my opinion, will be required below Bissel's Point, and possibly elsewhere, for the purpose of improving the harbor of Saint Louis.

The works now described are probably, as I have intimated, all that may be found essential for connecting the harbor permanently at all stages of the river with the main channels above and below it, and for fixing the navigation on that side of the river. But it is certainly very convenient for the navigating interest to have a channel not liable to shift as the river changes its volume. Now it is quite evident that if the strength of the current is found on different sides of the proposed new or western bed of the river abreast of Rocky Branch, in high and in low stages, we cannot reckon upon the constancy of the channel in the same line, especially where the bottom is composed of light and movable matter. But under the assumption respecting the variable influence of the Cascaret Island channels we are led to suppose that at some

seasons the current issuing from the narrows in front of Bissel's Point may be found to run most strongly towards the east and at others towards the west. Now, supposing a dam to occupy the position we have assigned to the one we have proposed, then the eastern current setting at periods of low water directly towards it and thence deflected westwardly, the resulting channel might differ in position from one which would be traced by a high water current flowing into the bend near Rocky Branch. We see, therefore, that although it is in our power, by means of works below Bissel's Point, to force a sufficient volume of water at the lowest stage of the river to the westward of Bloody Island, we can by no means be very certain, in the present state of our knowledge, that the channel would be found to occupy the same position at all times unless indeed we were to construct artificial sides for it, an idea forbidden by its cost. Supposing, then, what is very possible, that the surveys now in progress will have demonstrated the variableness of the main current near Bissel's Point with respects to its position and the direction which it takes at the several periods of high and low water, and likewise the connection of this phenomenon with the comparative force of the stream on the east and west sides of Cascarat Island during those same stages of the river, and the influence of these conditions upon the channels below the point, it follows, if we are required to fix the channel permanently in its position, that we must regulate the stream as it passes around the island, at least at the time of low water, and that we must have other works besides those already enumerated in order to increase the volume of water in the eastern channel. For this purpose our operations should ascend to the "chain of rocks" near the head of Sawyer's Bend, and to the gravelly bar above Cascarat Island—points already noticed in this report.

The gravelly bar should be thoroughly examined, and if found to be an impediment to the passage of the current into the eastern channel, and if it resists the current in its effort to deepen that channel, it should be removed to the requisite extent. Meanwhile, a dam or jetty should be constructed at and to extend from the chain of rocks to Cascarat Island, for the purpose of turning more effectually so much of the river, at its lowest stage, as may be found requisite, into the eastern channel. I suppose it to be obvious that this dam should extend quite across Sawyer's Bend channel, and that it should rise at least to a level with the bottom of the proposed excavation, or that the new should be excavated to the depth of the old channel, because fluids are prone to follow the direction of the deepest channels, supposing the bottom to be free from obstructions, and because, therefore, a mere jetty pushed to a limited distance into the deeper channel would be in effect but a partial prolongation of the chain of rocks. We would still find that the main current would continue to turn the head of the obstruction, and by the abrasion of the western bank of Cascarat Island, and by its erosive action on the bottom, having acquired for itself a sufficient area of discharge, it would return to the right bank below the jetty and resume its ancient course through Sawyer's Bend. Now the idea of excavating the new to the depth of the old channel is not to be entertained, because of the excessive cost of the project, and we see, therefore, that the proposed obstruction should completely close the channel to the height of the plane of the bottom of the contemplated excavation at the gravelly bar. This work, together with the excavation at the eastern channel, having been completed, time should be allowed to test their precise effect upon the channels near and for some miles below them, and the effect also which the new line of direction of the current may produce upon the form of the shores of the river. It is very probable that the increased volume of water in the eastern arm may be the cause of considerable abrasion of the banks. Its extent, however, cannot now be foreseen, although we must contemplate the necessity of providing for the defense of the banks near the entrance, and also near the termination of the improved channel. The right bank of the river also, near the chain of rocks, and especially where the proposed dam will unite with the shore, must be protected by a revetment of some extent.

It will be seen that no provision is recommended to be made for the protection of the western shore of Sawyer's Bend nor the Illinois shore east of Bloody Island. The defense of these in connection with the system of works I have enumerated is not called for, as I believe, by any considerations affecting the interest of navigation, because I do not apprehend that even the continued abrasion of these banks can very sensibly influence the results to be expected from that system.

It would be quite premature to speak of the details of the plans I have recommended, further than I already have, because we are without the information which would enable us to do so to any very useful purpose. We must wait for the surveys of Captain Cram before we can do that. It will not be mistimed, however, to add a few words to what has already been said concerning the means which ought to be employed for the protection of those portions of the banks, the defense of which may be found to be necessary for maintaining the channels in the positions best adapted to the purposes of navigation, and generally also the subject of the dams deserve some notice in addition to what I have already taken of them.

With respect to the defense of the banks, then, we know that short jetties or spurs projecting at intervals from the shore, have been tried as a means of protecting the

lower end of Bloody Island, and here as elsewhere they have not only failed to fulfill the purpose for which they were designed, but they have actually hastened the degradation of the banks they were meant to protect.* Captain Cram, enlightened by this experience, has very judiciously abandoned the idea of employing jetties, and proposes, as a substitute, to give a sufficient slope to the banks, and to cover this by a revetment. This method is employed elsewhere upon the Ohio River, and at some points on the Mississippi River above the Ohio, with a success that justifies the expectation of its efficacy if applied at almost any point within our limits; supposing, however, that the base of the revetted slope receives the impulse of the current obliquely, its ability to resist the perpendicular or direct attack of the higher freshets of this river may well be questioned.

In further recommendation of this mode of protecting the banks of rivers we have the experience of French engineers on that part of the Rhine which fronts the eastern boundary of Alsace. The character of this part of this river, viewing it in reference to our present subject, is most strikingly similar to the Mississippi near Saint Louis, allowances being made for the difference of volume only of the two streams. Jetties and other projecting works had long been employed there and ultimately abandoned as more decidedly injurious than beneficial to the banks. For the nearly last twenty-four years the method to which I have reference as being already in use upon our own Western rivers has been tried upon this part of the Rhine with such eminent success as to induce its general adoption, and it has now supplanted all others. The slopes are covered with stone easily handled, the larger towards the bottom and the smaller towards the top of the slope. The stones are laid without much attention to order or regularity, nor is there much solicitude as to the bond which the materials may have with reference to the soil on which they rest or amongst themselves. It is, however, manifestly desirable that the surface should not present very striking asperities to the current, which, also, ought not to be allowed to attack the soil, and for these reasons the form of the defended banks, whether in the horizontal or inclined planes, ought to be unbroken lines and as great an extent as possible ought to be executed at once.

It should be remembered, however, that wherever the current sets along the foot of a bank whose side is defended against the lateral action of the stream, if the bottom is incapable of resisting its force, we find always excavations more or less deep in the bed of the river near the base of the bank, because the neighboring soil can no longer be swept into them. For this reason a sufficient provision of materials of stone, brushwood, fascines, &c., is to be kept at hand for extending the foot of the revetments as far as the action of the current may indicate the necessity of further defense. But at every locality there is a limit to the depth to which the abrading power of the stream can extend, and this limit is compounded of the volume and velocity of the stream and the resistance of the bottom. The depth which it will attain under ordinary circumstances will therefore be reached very soon, and hence we conclude that it will not require a very long period of time to carry such a system of defense to its final completion. We must except from this conclusion, however, the contingency of partial repairs which the work from time to time will doubtless require whatever may be the state of the river, and also the additional work consequent upon excavations near the foot of the slopes, the result of the action of extraordinary freshets. This mode of protection, which is equally recommended by an extensive and enlightened experience, and by its comparative economy is, in my opinion, the best that we can apply wherever they are susceptible of and need protection.

Respecting the dams, I have but little now to add to what has already been said on that subject. An experiment has been made towards the construction of one between Kerr's and Bloody Islands. That work, to the extent to which it was carried, was composed exclusively, I think, of loose stone and some brushwood † thrown into the river in the proposed line of direction of the work, but otherwise without much regard to regularity in the arrangement of the materials; in other words, it was rip-rapped. The original design was not carried out for want of the requisite funds. Its efficiency has not, therefore, been fairly tested. Its present condition has been examined by the officer in charge of the works, and the result of his examination is in the possession of the bureau. Much of the work has disappeared, especially at points exposed to the strength of the current. Whether the materials have been swept away or have subsided in the soft bed of the river, I know not; but most probably, I think, their disappearance, or at least that of the heaviest of them, should be attributed to the latter cause. For my own part, I can see no reason to doubt that a sufficient dam can be made, at least for that locality, and probably, also, at the Chain of Rocks, of loose stone thrown into the river at random, but in the proper line of direction. The main body of the work should be composed of stones of a size sufficient to resist the

*Jetties, however, do not always lead to the destruction of the banks they are connected with. At points remote from the action of the main currents and where there is already a tendency to accumulation they have the effect to accelerate that process.

†Part of it was defended by piles.

current, and this may readily be determined when we know the maximum velocity of the stream. Undoubtedly they will settle to a very considerable depth into the bed of the river—to what extent, either by reason of their own gravity or the erosive action of the currents upon the foundation of the work, is at present matter of very loose conjecture; but certainly, I should think, not deeper than any other sufficient combination of materials. It is, as I have already said, of some importance, in view of the stability of at least the crest of such a work, that it should not be raised much above the low-water line.

The body of the work being composed of large stones, chosen mainly with the view of resisting the force of the stream, we might reasonably apprehend that the currents would find their way through the vacant intervals which necessarily they would find between them, unless they were filled in with smaller stones or gravel, and this precaution as well as the use of brushwood is recommended in the event of the further prosecution of that plan.

Two other methods have been proposed by Captain Cram, either of which, if established upon a sufficient breadth of base, would no doubt possess the requisite strength and stability. I am not prepared, however, to compare them with that on which the former work was undertaken with reference to the question of cost.

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It will be seen from what I have now said that there is some difference of opinion between Lieutenant-Colonel Long and also Captain Cram and myself respecting the works required for the improvement of the harbor of Saint Louis, both as to the works themselves and the order of time in which they ought to be executed. The principal point of difference respects the proposed dam and its dependent works at the Chain of Rocks. Colonel Long as well as Captain Cram proceeds upon the assumption (which may possibly be well founded) that the volume of water flowing around the eastern side of Cascarat Island, at some stages of the river, is wanting in the force necessary to counteract the tendency which the stream coming down from Sawyer's Bend may reasonably be supposed to have toward Kerr's Island or the Illinois shore, in consequence of its superior volume and velocity, and therefore regards the dam as necessary under all circumstances and of prime importance, and to be commenced with the least practicable delay.

I should avow to the Department that I was once myself much inclined to this view of the subject, because I saw then no reason for questioning the inefficiency at all times of the eastern current. Subsequently, however, having the chart of Captain Lee, already referred to, before me, and having examined it over its whole area with care and attention, I found much reason for questioning that supposed inefficiency. Considering well the form and position of the western shore above and of the eastern shore at and below the narrow pass abreast of Bissel's Point, I did not doubt that if the force of the stream forming from the eastward of Cascarat Island were annulled, the main current and consequently the deep channel would be found on the eastern instead of the western side of the river at that place. It is evident, however, as I have before said, that when the river is 12 feet above its lowest stage, that the main channel lies directly under Bissel's Point, and hence I infer that at this stage of the river certainly, and at still lower stages very probably, the force of the eastern current suffices to give the resultant or united current the direction which was to be expected from the effects of the proposed dam and works at the Chain of Rocks, and the sole purpose of their execution. Now, so far as I am informed, it is nowhere proposed to control the freshets which have a higher elevation than 12 feet above low water, and the influence of this eastern current at higher stages can therefore have no bearing on the discussions respecting those works.

We are limited, then, to the inquiry whether at any lower stage than 12 feet the resultant current and main channel in front of Bissel's Point has a position or direction other than that exhibited on Captain Lee's map, and this inquiry, I think, ought to be answered clearly and certainly in the affirmative before we can safely affirm that this dam is under all circumstances necessary and of prime importance.

Its necessity is manifestly, in my opinion, contingent upon the development of this fact, the evidence of which I have not yet seen. We have, it is true, the reports of Colonel Long and Captain Cram; but, if I apprehend their tenor correctly, they announce opinions merely respecting it and not facts. I repeat, then, that if upon investigation it is found that at low stages of the river the volume of the stream coming from the eastern side of Cascarat Island is insufficient to give to the main current in front of Bissel's Point the direction it should have with reference to the improvement of the channel below that point, and if the department deems the maintenance of the channel between Bissel's Point and the city upon a fixed and determinate line, at all the lower stages of the river, as of sufficient importance to justify the cost, then the dam and its dependent works at the chain ought at once to be undertaken, and not otherwise.

Colonel Long and I agree as to the proposed revetment of the west bank of Sawyer's Bend, namely, that it is unnecessary. We agree also that some revetment will be

wanted east of Cascarat Island, on both sides of that channel, contingent upon the erection of the dam at the chain.

As respects the dam or dams for the arm of the river between Bloody Island and the Illinois shore, I have given my views very much at length in the proper place. Colonel Long views them in the light of substitutes for a revetment, having for its object the protection of the Illinois shore, and contingent upon the effects to be produced by the contemplated dike or dam and channels near the head of Cascarat Island. He thinks also, and in this we agree, that a revetment of greater or less extent along the west side of Bloody Island is likely to be required "not only for the preservation of the island, but as a means of giving to the currents through the Saint Louis channel their proper course and direction."

The height of the dams seems to be fixed at 5 feet above low water in all cases, and the depth of dredging at $4\frac{1}{2}$ feet below the same plane; but I do not find that the course of reasoning nor the facts which have led to the adoption of these dimensions are given in any of the reports before me. For my own part, I presume, as I have already said, that the proper height will depend, in some measure, upon the relative position in the vertical plane of the surface of low water at the dam and in the proposed channels, and that, these not being now known to us, we cannot yet determine exactly the height of the dams or the depth of the excavations.

All of which is respectfully submitted.

JAMES KEARNEY,

Lieutenant-Colonel Topographical Engineers.

Col. J. J. ABERT,

Chief of the Corps of Topographical Engineers.

J.

REPORT OF CAPTAIN T. J. CRAM, CORPS OF TOPOGRAPHICAL ENGINEERS.

OFFICE OF PUBLIC WORKS,

Saint Louis, Mo., 31st March, 1845.

SIR: Your order of 27th September last directed me to make "an accurate survey of the river from about the lower end of Kerr's Island to about the upper end of Duncan's Island, in which the soundings and character of the bottom were to be carefully ascertained and exhibited on a scale of 12 inches to the mile.

Presuming the results of this accurate survey may be needed by you in forming your final decision as to the plan for the preservation of the harbor, I herewith transmit an exact traced copy of the chart which I have drawn upon the prescribed scale.

I. LOW AND HIGH WATER LINES.

On the sheet next to what is exhibited as water you will see a distinct full line. This is the exact delineation of the water line at the lowest stage in the month of December, 1844, along the banks of the main islands, the sand deposits contiguous to the islands, and of the isolated dry sand bars. Inland from this low-water line is drawn a full distinct line, which is the exact delineation of the usual high-water line on all the banks, not only of the main but also of the islands. Between these two water lines the space on the sheet is the projection of the banks, or so much thereof as contained between the two indefinitely extended surfaces of low and high water stages.

Kerr's and Duncan's are islands only in high stages of the river. In low stages the sloughs between them and the main are perfectly dry. The bed of Kerr's Island slough is $9\frac{1}{2}$ feet above the stage of December, 1844, and the bed of Duncan's Island slough $2\frac{1}{2}$ from feet the same stage. The stage of December, 1844 is $5\frac{1}{2}$ feet above the stage of December, 1843. Therefore, in plans for the improvement of the harbor having reference to low water, these two islands are to be regarded as belonging to the mainland.

II.—SOUNDINGS.

Those marked with the red lines were taken in the month of October, 1844, and reduced to the stage of water in December following; those not thus marked were taken during the stage of December, 1844. If the bottom of the river had remained permanent in the interval, of course those of October could be compared with the soundings in December. But inasmuch as the bottom, which is composed of sand, is continually shifting, the soundings at one stage cannot be compared with those at a different stage. Hence, if we desire a knowledge of the shape of the bottom at any particular stage, the only possible way of acquiring it is to take the soundings at this stage.

The soundings are referred to the low-water stage of December, 1844. The mean of

all the soundings in the line from B (head of Bloody Island) to L (foot of Kerr's Island) is 9.1 feet; the mean of all the soundings in the line from B to J is 7 feet. The velocity of the water in the section along the former line is very nearly the same as in the section along the latter.

The soundings show a decided enlargement of the deposits surrounding the head of Bloody Island, and that the extension is decidedly towards the eddy in the vicinity of I. These are strong evidences of the city channel being in the condition of being cut off or obstructed to a degree precluding the passage of boats in low stages.

III.—ILLINOIS CHANNEL EAST OF BLOODY ISLAND.

The cross-section of this channel is continually increasing in consequence of the abrasion of the Illinois bank, which is composed of material easily washed away. The rate of this abrasion has been measured for different periods in the last thirty years.

From 1814 to 1837, a period of 23 years, the strip washed away from this bank for an extent of 2 miles was 750 feet wide.

From 1837 to 1843, a period of 6 years, the strip washed away was 300 feet wide.

From 1843 to 1844, a period of 1 year, the strip washed away was 135 feet wide.

Hence it is seen that the abrasion is not only continuous, but it becomes greater and greater every succeeding year.

IV.—CITY CHANNEL WEST OF BLOODY ISLAND.

The cross-section opposite the head of the island is becoming smaller and smaller; the width and depth, both, are being contracted. The shore there operates like a dam. The water falling over the summit produces a deep pool below it, which pool extends along down the front of the city, which is the cause of the soundings in this part of the harbor being so much greater than are observed on the line from B to J. The operation that has been and still is going on in reference to this channel is precisely similar to all others in the Mississippi, where one channel is sacrificed or reduced to a mere slough by the enlargement of the complemental channel on the opposite side of an intervening island.

V.—QUANTITIES OF WATER IN THE CHANNELS.

The quantity of *running* water in the Illinois channel is progressively increasing, while that running in the city channel is correspondingly diminishing. The quantity that passed over the shoal at the head of the city channel into the harbor in December, 1844, during a given time, was expressed by $7 \times 6390 \times \sin 19^\circ 30' \times c$. And the quantity passing into the Illinois channel, in the same time, was expressed by $9 \times 5544 \times \sin 19^\circ 12' \times c$. By taking the ratio of these two expressions we find the quantity *running* into the city channel to the quantity *running* into the Illinois channel as 1 is to 1.0101, giving more running water to the latter than to the former.

VI.—RATES OF FALL.

The total fall in the surface of the river from R to W in December, 1844, was 2.526 feet, and the total distance run over by the water to attain this fall was 20,466 feet. But the rate of the fall is by no means uniform. Beginning at the upper end of the prism, and dividing it into parts, we have the following table of falls in the consecutive parts:

From R to S, 3,912 feet;	total fall, 0.507 foot;	rate of fall, 0.684 foot per mile.
From S to T, 2,200 feet;	total fall, 0.060 foot;	rate of fall, 0.144 foot per mile.
From T to U, 5,140 feet;	total fall, 0.614 foot;	rate of fall, 0.631 foot per mile.
From U to V, 2,894 feet;	total fall, 0.580 foot;	rate of fall, 1.057 foot per mile.
From V to W, 6,320 feet;	total fall, 0.765 foot;	rate of fall, 0.639 foot per mile.

This table, together with the *direction* of the current in the city channel, which is attacking the west bank of Bloody Island just below A, and the direction of the current attacking the bank above F, will at once lead to the determination of the position that should be assigned to a dam from the head of Bloody Island to the Illinois bank to remedy the evil pending over the city channel.

VII.—BED OF THE RIVER.

Throughout the whole portion exhibited on the chart the bed is composed of sand deposits down to a level of at least 25 feet below the stage to which the soundings are

referred, that of December, 1844. Whatever be the works put into the river, they must rest upon a sand foundation that is possessed of extreme mobility.

VIII.—PROTECTION AGAINST ABRASION.

The idea entertained by some of stopping the abrasion of a bank by jutting out therefrom at certain intervals encroachments transverse to the direction of the abrading current is perfectly fallacious. Witness the works of this kind formerly constructed by the city authorities on the west bank of the lower end of Bloody Island, in the vicinity of F. There is a channel 200 feet wide and from 12 to 40 feet deep between the three lower jetties and the bank; and a like channel around the upper one has been prevented from being cut *only* by the accidental lodgment of a long hulk parallel with the bank just below this jetty.

The three lower jetties, together with the remains of the work constructed by the United States, seen extending down perpendicularly to the lower jetty, will in a few more years occupy the very middle of the channel. They are now quite serious obstructions to the navigation. On top of the old United States work a heavy-laden boat coming into the harbor at night is liable to fasten herself.

IX.—STAGES OF WATER.

Herewith is also transmitted a drawing exhibiting to the eye the relative stages of the Mississippi at this place for every day since 1st May, 1843.

The axis or line of reference A X is divided into equal intervals of time of one day each, and the points of division are numbered in order with each day of the month. At these points of division ordinates are erected, and on them the heights (in feet and inches) of the water on the respective days are marked off from a scale of equal parts.

Through the points thus determined a curve is traced exhibiting the daily variations in the stage of the water. Above this curve of stages, and parallel with A X, a dotted line is drawn and the ordinates produced up to this line. The numbers at the extremities of the produced ordinates recorded *above* the dotted line express the rise in inches and those *below* express the fall for every interval of one day.

The axis of reference A X has been drawn through the low stage of December, 1843, which stage was uniform for several days, and of course all the other stages are referred thereto in the drawing.

The flood of the summer of 1844 was highest on the 27th of June. On that day the water was 38 feet 9½ inches above the low stage of December, 1843. The stage that I assume for *usual* high-water is 24.5 feet above the axis of reference A X, which makes the summer flood of 1844 14.25 feet above *usual* high-water. The disastrous consequences of this flood will long be remembered throughout the low lands of the Missouri and Mississippi. Farms were submerged, orchards killed, crops destroyed, houses, fences, and farming utensils swept away. Cattle, horses, sheep, and other domestic animals were drowned, or driven to the elevated grounds and there starved. For hundreds of miles the scene presented one widely extended sea of desolation, ruin, and misery.

The effect upon the top soil of the bottom lands has been, not to wash away the ground, but more generally to leave a deposit, thereby elevating the immediate banks of the river. In some places this deposit is of a rich character, at others it is of a fine sand, utterly unfit for cultivation. In many instances for miles along the banks the depth of this deposit is from one to six feet. The deposit lies in the form of ridges and furrows, indicating clearly the direction in which the extraordinary high-water currents coursed over the ground.

I have the honor to be, respectfully, your most obedient servant,

T. J. CRAM,

Captain Topographical Engineers, Superintendent.

J. J. ABERT,

Colonel Corps Topographical Engineers.

K.

EXTRACT FROM REPORT OF LIEUT. COL. S. H. LONG, CORPS OF TOPOGRAPHICAL ENGINEERS.

OFFICE OF THE WESTERN RIVER IMPROVEMENT.

Louisville, December 1, 1846.

SIR:

Appearances on the river above and at Saint Louis seem to authorize the conclusion that the quantity of water passing through the harbor between Saint Louis and

Bloody Island in a low stage compared with that passing between the island and the Illinois shore at the same stage, is somewhat greater at the present time than it was two years ago, hence the condition and prospects of the harbor are quite as favorable now as they were in the fall of 1844. Numerous indications in the bed of the river, between the mouth of the Missouri and Saint Louis, especially the formation of a sand bar of considerable magnitude on the west side of Kerr's Island at its lower extremity, an increased width and depth of the channel across the bar near the upper ferry landing on the Missouri side, &c., all contributing to throw the low-water currents towards that side, and to increase the volume of water that passes through the harbor in a low stage, may be adduced as proofs in support of the conclusion.

The water thus augmented in the harbor instead of passing out of the head of Duncan's Island as formerly, has worn for itself a channel at and near the foot of Bloody Island, and passes off toward the Illinois shore through the channel thus formed, leaving a large area between it and the lower landings of Saint Louis and above the head of Duncan's Island, over which the sand has accumulated to such an extent that the old channel passing off in this direction has been filled up and a broad sand bar has been formed, across which the low-water depth is too inconsiderable to admit the passage of steamers of the lightest draught. In consequence the lower part of the city and its landings have been rendered inaccessible to boats of burden during a low stage of the river.

The present channel at the lower end of Bloody Island has a depth of 8 to 20 feet and includes the wing-dam about half a mile in length constructed under the direction of Captain Lee many years since together with its abutment or pierhead originally incorporated with the island. And two or three of the stone jetties above the dam constructed at the expense of the city, since the erection of the dam, all of which were in like manner incorporated with the island. The abrasions on this part of the island have been carried to such an extent that the present distance between the pier-head and the island shore, in the opinion of the city engineer, is about 260 feet and the depth of water 10 to 18 feet, that the distance between the first jetty above the pier-head and the shore is about 411 feet, and the depth about the same as just before stated; that the distance between the second jetty and the shore is about 100 feet, and the depth 12 feet; and that the distance between the third jetty and the shore is about 40 feet and the depth 6 feet. The channel on the right of the dam descending, is much broader, but affords a low-water depth of 3 to 5 feet only. The position of this channel is about one-fourth of a mile from that occupied by the main outlet of the harbor a few years ago, when a broad sand bar, impassable for boats in a low stage of the river, extended downward from the lower point of Bloody Island in a direction toward the head of Duncan's Island, and forced the main channel in that direction to a position near to the locality last mentioned.

My late interviews with the city authorities, in reference to the improvement of their harbor have resulted in a mutual understanding of the following import:

1st. That measures be taken for repairing the breaches in the wing dam and extending said dam upward and across the present channel, to the western shore of Bloody Island, in the direction of the existing dam and in connection with the jetties situated above the dam, the object of this work being to block up the present channel at the head of the dam or between it and Bloody Island and to compel the water tending in that direction to pass across the bar at and above Duncan's Island; whereby this bar is expected to be washed away and a channel to be formed through it by which boats may have a free passage to and from the lower or southerly landings of the city. This part of the work to be done at the expense of the city corporation and under the direction of the city authorities.

2d. An appropriation of \$25,000 has been made by the city authorities for the purpose contemplated in the preceding paragraph. Moreover, a contract has been made for stone to be delivered and deposited on the line of the work at the moderate price of 90 cents per perch of twenty-five cubic feet.

3d. That any revetments or other works required to secure Bloody Island against abrasions on the west side near the head of the island be planned and executed under the direction and at the expense of the United States and by means of any future appropriation hereafter to be made for the purpose.

4th. That the main object and great desideratum to be attained by means of appropriations on the part of the general government is the diversion of a portion of the water from the east to the west side of Bloody Island or from the Illinois to the Missouri channel.

5th. That the object or diversion just mentioned is to be effected in the manner proposed by the Topographical Bureau, viz, either by a dam or dike extending from the head of Bloody Island, obliquely upward and across the Illinois channel to a point at or near the town of Brooklyn; or by dredging a channel of requisite width and depth leading obliquely downward from a point in the Illinois channel opposite to the foot of Kerr's Island, to the harbor of Saint Louis; or by both of these methods of improvement combined.

6th. That the unexpended balance of the last appropriation of Congress, still remain-

ing applicable to the improvement of the harbor, is about \$22,700, and that the city corporation wish this balance to be expended as early as practicable under the direction of the general government in a manner conducive to the attainment of the object contemplated in the two preceding paragraphs.

7th. That the work to be done by the corporation be commenced immediately and prosecuted in conformity to the plans and contracts already prepared for that purpose, and that the work to be done by the United States be commenced as early as practicable in the ensuing spring and prosecuted with diligence to the extent justifiable by the means applicable thereto.

With respect to the manner of constructing the contemplated dike or dam mentioned in the fifth paragraph, I take leave to offer a few remarks based on personal observations of a recent date.

The structure under consideration must be based on the sandy bed of the river without any solid foundation for its support. However questionable the stability of dikes thus sustained, we have numerous examples on the affirmative side of the question. The dam at Cumberland Island, in the Ohio, is based upon a bed of sand of an unknown depth. It is constructed of stone and brush without piles or crib work, the stone having been deposited after the manner of riprap stone work, which is characteristic of the dam from its base to its summit. The stones have been occasionally swept from its summit by floating ice and other drift, but the dilapidation in this way has never been very considerable; on the contrary, the work appears in all parts sufficiently stable except near the head of Cumberland Island, where, owing to the elevation of the bar at the time the dam was built and the comparatively small body of stone deposited on this part of the line of the dam, a breach has been formed of a capacity to admit a large quantity of water. This accident might have been readily prevented by increasing the riprap work on that part of the dam at the commencement of the rupture.

Examples of a similar character are to be witnessed in the Ohio River, at the island called the Sisters, Three-mile Island, Scuffletown bar, and French Island, all of which are of rip-rap work without cribs or piles.

The jetties near the foot of Bloody Island and a work reared for the protection of the ferry landing opposite to Saint Louis, formerly connected to the Illinois shore but now completely insulated and surrounded by water, have in like manner been reared upon sandy foundations of unknown depth by means of riprap work exclusively of stone, and remain as monuments testing the stability of works of this sort.

Should it be deemed advisable to protect the summits of the dams from the ravages of floating ice and drift, this object can be readily accomplished by crowning the riprap work with a crib-work filled with stone and extending downward a foot or two below the surface of extreme low-water. I would add the passing remark that in rearing dikes, dams, &c., their effect should be carefully observed from their commencement to their completion, the latter of which should be regarded as fully achieved when the flow of water across their lines has been sufficiently checked to subserve the purpose for which the work is intended.

With respect to the formation of a channel across the bar at the head of Bloody Island, this operation must be performed by means of a dredging-machine, and other appropriate apparatus operated by steam power. The cost of such a machine, &c., endowed with the power of self-locomotion, will be about \$20,000. The propriety of such machinery for operation at Saint Louis and at other points on the Western rivers cannot be doubted, and in the event of another appropriation by Congress for the improvement of these rivers, I would unhesitatingly recommend that funds be set apart for its construction and use.

The cost of the contemplated dam, of the character above given, from the head of Bloody Island to a point at or near Brooklyn, on the Illinois shore, may be exhibited as follows:

Riprap foundation raised from the bottom of the river to an elevation of 2 feet below surface water at the lowest stage, 50,000 perches of 25 cubic feet, at \$1	\$50,000
Crowning of crib-work filled with stone, 3,420 linear feet, at \$2 per foot.	6,840
Superintendence and contingencies, at 10 per cent.	5,684
Amounting to.	62,524

The cost of dredging a channel across the bar at the head of Bloody Island, the length of the channel being about 4,000 feet, its width 200 feet, and its depth below the surface of extreme low-water 4 feet, is estimated as follows:

Excavation of 147,000 cubic yards, exclusive of prime cost of dredge-boat, &c., but including a fair allowance for their use, wear, tear, &c., at 20 cents per yard	\$29,400
Superintendence and contingencies, at 10 per cent.	2,940
Amount, exclusive of cost of dredging apparatus	32,340

In conclusion, I take leave to recommend that the work on the dam above considered be commenced at the earliest practicable date of the ensuing season by causing about 20,000 perches of stone to be deposited at the bottom of the river along the entire line of the dam, with the certainty that the stone will remain as deposited and form a proper substratum for the work subsequently to be done. Also, that measures be taken, with any means applicable to the improvement of the western rivers, for the construction of a locomotive dredge-boat, not only for opening the proposed channel across the bar at the head of Bloody Island, but for general use on the western rivers.

I have the honor to be, sir, very respectfully, your obedient servant,

S. H. LONG,

*Lieutenant Colonel Topographical Engineers,
Superintendent Western River Improvements.*

Col. J. J. ABERT,

Chief Topographical Engineers.

L.

REPORT OF MR. HENRY KAYSER, SUPERINTENDENT OF SAINT LOUIS HARBOR IMPROVEMENTS, TO THE BOARD OF ALDERMEN OF THE CITY OF SAINT LOUIS, MISSOURI.

The following report was read and referred to the committee on harbor :

SAINT LOUIS, *February 26, 1849.*

GENTLEMEN: By a resolution of the honorable board of the 19th instant I have been called upon to communicate the estimate of the actual cost and outlay necessary to effectually carry into success the several works contemplated by the resolutions adopted by the legislature of Illinois respecting the completion of work on the dike, as communicated by his honor the mayor in his communication of this day; and, further, to specify in said communication the separate cost of the several dikes or works in said resolutions specified, as well as the amount of money necessary to complete said work, over and above the amount of money already appropriated or set apart, and at this time unexpended, for the harbor improvement aforesaid.

For a correct understanding of the whole subject referred to in said resolutions, and of the data herein furnished in compliance therewith, it will be necessary, first, to advert to the general features of the works planned for the improvement of the harbor.

The western or Missouri shore of the Mississippi River in front of this city is nearly altogether rock-bound, and therefore stable and unencroachable by the waters of said river; the eastern or Illinois shore of the same opposite the city and for many miles above and below is alluvial, unstable, and of such incoherent texture that it yields without the least opposition to the action of the waters of the river. As a matter of course, in all changes of the same, produced by causes innumerable and intraceable, as long as it flows in its immense course uncontrolled by man and art, we perceive a tendency of the channel toward the fragile and yielding shore on the Illinois side; and within this century a strip of land about 1,000 feet in width has been gradually worn off the same, and, correspondingly, bars of more or less extent have been left in the bed of the river in front of Saint Louis. But the very instability of the shore on the Illinois side, drawing the channel toward it, is detrimental to it and makes the same unavailable and unfit for the erection of houses and building a city on it, and gives the Missouri side naturally a decided advantage. Hence, the uncontrovertible conclusion that the interests and wants on both sides of the river in regard to its improvement, in the principal bearing, are identical, and tend to the accomplishment of the same object, which is, to give the Illinois shore stability, so as to render the land in its rear safe for building, and to retain and guarantee along the Missouri shore a sufficiency of water. With this view the city of Saint Louis, in part with the assistance of the United States Government, has at all times based the improvement of her harbor upon the making of a shore for the Illinois side as near as may be parallel to her own stable one, with a way between them of such size as to afford a sufficient passage for the water during the highest stages of the river, and depth enough during the lowest stages of the river.

Accordingly, the western shore of Bloody Island, as about coinciding with the line of the shore contemplated to be constructed for the Illinois, has been revetted; a dam has been built along said line from the foot of said island southwardly, for the purpose of protecting and assisting the growth of said island in that direction; further, the building of a dam has been commenced, running from the head of said island upwards to the town of Venice, where the contemplated shore-line will meet the natural present Illinois shore, for the purpose of protecting and assisting the growth of said

island northwardly; and lastly, in order to support these works along the contemplated shore-line, and give them a direct connection with and brace to the present Illinois mainland, and to throw the water now running on the eastern side of Bloody Island into the main channel, and thereby accelerate the deposition and accumulation of sand and sediment, so as to bring about, as early as possible, a connection of the island with the mainland, the construction of a dam near the foot of said island, from the contemplated shore-line directly across to the Illinois mainland, has been commenced. It was in the construction of this last-mentioned dam and that running from the head of Bloody Island to Venice, that the authorities of the State of Illinois, last summer, interfered, and it is in regard to the further construction of these dams that the resolutions of the general assembly of Illinois referred to, and authorizing and empowering the city of Saint Louis to proceed with and complete the works now in progress of construction within the territorial limits of the State of Illinois for the improvement of the harbor, contain certain terms and conditions.

Having made these few remarks, I will now state wherein these terms and conditions, so far as they affect the work itself, consist. It will be proper, though, to mention, first, that, according to the whole tenor of said resolutions, authority for the construction of said works within the territorial limits of Illinois is only given upon the express understanding that such construction shall not impede, obstruct, or in any manner injure the navigation of the main channel of the Mississippi River; that consequently all other considerations, terms, and conditions, must be subservient to the preservation of the navigation in the main channel, a proviso dictated by wisdom, and at all times by the city, as well in the adoption as in the execution of her plans, heretofore scrupulously observed, and, it is to be hoped, hereafter never to be lost sight of.

Regarding the construction of the dam from the head of Bloody Island, the terms and conditions are as follows:

The city of Saint Louis shall, in accordance with the general plan of said works, construct the dams or dikes from the main Illinois shore to the dam or dike running from Venice to the head of Bloody Island, and which dams or dikes are designated on the map of the works compiled in January, 1849, by Henry Kayser, superintendent of the works, as W and V, one running from Brooklyn, and the other from the line dividing Madison and Saint Clair Counties, to said main dike from Bloody Island to Venice; said two cross-dams to be constructed simultaneously with such main dike, and the said main dike and cross-dikes to be completed within two years from the adoption of the resolutions. These conditions required not more additional work than was originally contemplated.

The said dam from Venice to the head of Bloody Island will have a length of about 7,000 feet, commencing at and gradually receding to more than 1,000 feet distance from the main Illinois land. At the western edge of the contemplated shore it is not intended to be raised more than 5 or 6 feet above low water, and therefore will not require a greater quantity of material. To give it strength and connection with the mainland, create dead water, and prevent the cutting of a channel through and in the rear of it and facilitate the making of deposits and their connection with the mainland, cross-dikes have to be built from it to the mainland, which, near their eastern ends, gradually rise up to the surface thereof and simultaneously protect the same against the effect of the water during the higher stages, when flowing over the main dam. The fact is, these cross-dikes of right ought to and would have been built before said long dam was commenced, if only the success of the works, and not other interests, would and could have been consulted. Because the long dike will eventually prove to be nothing more than a kind of revetment along a shore, the land in the rear of which has been made by the gradual formation, elevation, and connection of sand-bars, produced by itself and the cross-dikes, but solely retained and protected by the latter.

The said conditions only define the location of two of said cross-dikes, and these locations are well selected. They further stipulate that these two cross-dikes and the main dike shall be completed within two years. There is, of course, no positive calculation possible as to the progress of such works depending upon stages of the river, and its own effects upon the river; but, under ordinary circumstances, and assuming that no uncommon interruption will take place, delaying or preventing the construction of these dikes, I cannot see why within said period the same could not be carried to such a state of completion as is needed to answer the purposes they are intended for. As to the cost, I cannot be certain, but believe, that the appropriation made therefor will suffice, assuming and calculating upon the sand-bars on the downward course of the main dam continuing to form and grow so rapidly as was the case last year, so that the same rise above its contemplated elevation, and thereby for the first make its construction for a long distance altogether superfluous and even impossible.

Regarding the construction of the dam near the foot of Bloody Island straight across to the Illinois shore, the conditions are as follows:

The city of Saint Louis, as soon as practicable, shall complete and construct a road or highway over said dam so as to afford a safe and commodious highway from the

mainland on the Illinois shore to and upon Bloody Island. By recollecting what I have stated as to the primitive object of this dam, it will appear that the said condition in addition thereto requires it to be built so as to serve as a road, a use which it was easy to foresee it would be eventually applied to. To serve merely as a dam it would have been only necessary to make it of a size so that the sloping sides intersect at its highest elevation. To serve also as a road its size must be increased, so that at its greatest elevation it has a top surface of a width sufficient for a road. To accomplish this, however, no definite time is specified. The condition only stipulates that the road shall be completed as soon as practicable; for the consideration of not in any way injuring the navigation of the main channel of the river, to which, as above stated, all other considerations have to be subservient, would make the propriety of stipulating such time, or the possibility of complying with a stipulation of the kind, quite unquestionable.

The dam, whether built to serve merely as a dam or to serve simultaneously as a road, must be raised very gradually and in accordance with its effects upon the main channel. I ever was of the opinion that a period of two or three years should be employed for building it to its highest elevation, unless experience should show that it can be carried on faster. Therefore the additional cost to be incurred for making the dam wide enough for a road, as required by said condition, cannot well be estimated with accuracy. It depends very much upon the length of time during which its construction is carried on, as accordingly, more or less, the accumulation of sand and other sediments it will create can be made use of toward its formation. I suppose that from \$12,000 to \$18,000, in addition to the former appropriation, will suffice, but will not be needed before two years.

On the whole, I beg leave to express it as my opinion that, as the construction, regarding progress and cost, of all these works is subject to difficulties, obstacles, and delays, caused by nature and men, and not to be foreseen, the compliance with any terms and conditions with which the same may be incumbered ought to be held also subject to such difficulties, obstacles, and delays.

Lastly, it seems to me appropriate to add the following remarks:

All the different works so far constructed and in progress of construction tend directly only toward the formation of the contemplated shore opposite the upper and central part of the city. Other structures will be required to continue such formation opposite the lower or southern part of the city and remove the large bar in front thereof. The dam mentioned above as running from the foot of Bloody Island southwardly extends only as far as the direction of Market street. Here the water, instead of being directed towards said bar, is allowed to spread again over the entire width of the old bed, and seeks the old channel in the eastern part thereof. To give it the desired direction and throw it into the water-way west of the contemplated Illinois shore line, and as a necessary result wear off said bar and cause the formation of bars and land in the rear of the shore line, in continuation of and connection with the bars of land formed and intended to be formed by the works higher up, I would, as a further link in the chain of the works for the improvement of the harbor according to the plan above mentioned, recommend the erection of a dike to run from the present Illinois shore somewhere above the mouth of the Cahokia Creek straight across towards the contemplated shore line. This recommendation appears to me particularly appropriate at present, as during the construction of the dam from the foot of Bloody Island to the Illinois shore, and before the same is completed so far that it can be used as a road, and the ferry landing can be at its western terminus on Bloody Island, it will be very difficult, and perhaps impossible, for the ferry-boats to reach the Illinois shore when the stage of the river is so low that the same cannot pass over the bars, which are intended to and doubtless will be created by said dam; and as the proposed dike could be built with the view and in a manner to serve, during the existence of the emergencies referred to, as a ferry landing for the lower part of the city.

All of which is respectfully submitted by your obedient servant,

HENRY KAYSER,

Superintendent Saint Louis Harbor Improvements.

To the honorable BOARD OF ALDERMEN

Of the City Council of Saint Louis.

M.

EXTRACT FROM REPORT OF LIEUT. COL. S. H. LONG, CORPS OF TOPOGRAPHICAL ENGINEERS.

OFFICE WESTERN RIVER IMPROVEMENTS,

Louisville, October 18, 1849.

SIR: In obedience to your instructions of September last, requiring an examination of the works in progress at and near Saint Louis, for the improvement of the har-

bor of that city, I repaired thither with all practicable dispatch, made the requisite examinations, and now have the honor to report the results of my observations and inquiries in reference to the duties assigned me.

A few preliminary remarks relating to the changes that have taken place in the channels, bars, and river-banks within the last twenty to twenty-five years will enable us the better to judge of the character and condition of the harbor at different dates, and of the utility and efficiency of the means heretofore employed for its improvement, also of the benefits likely to result from present and future efforts for the attainment of that object.

A residence in Saint Louis in the years 1816, 1817, and 1818, and occasional visits in that neighborhood subsequently made, especially between 1840 and the present time, have enabled me to form a tolerably intimate and extensive acquaintance with the changes that have taken place in the harbor and in the river channels communicating with it since the earliest date above mentioned.

At that time the channel between Bloody Island and the Saint Louis shore was known to be very deep and occupied the entire space between the island and the shore. Its general depth no doubt exceeded thirty feet, and was beyond the reach of soundings by the ordinary means then in use for ascertaining river depths. Almost the entire volume of the river, both in low and high water, then flowed through this channel. At that time and for several years afterward no fears were entertained as to any changes affecting the depth of the harbor or the volume of water flowing through it, nor was there any apparent danger of future impediments in the way of a free and easy communication with the harbor, both above and below the city, except from the enlargement of a sand-bar already formed and annually becoming more and more spacious at the lower part of the city. In 1820 this bar had become entirely insulated, and about this time assumed the name of Duncan's Island.

Soon after the year last mentioned, abrasions began to take place on the Illinois shore opposite to the lower end of Bloody Island, and from the Ferry Landing on that side downward towards the mouth of Cahokia Creek. These occurrences gave evidence that the volume of water in the Illinois channel was gradually increasing, and of course that the volume in the Saint Louis channel was diminishing in a corresponding degree.

The causes by which the results just mentioned were produced continued to operate; the abrasions on the Illinois shore grew more extensive and gradually traveled upward on that side of the river, while the flow of water through the Illinois channel became more and more copious, at the expense of a corresponding reduction of the quantity flowing through the Missouri channel.

The causes of these changes are to be sought for in connection with those that occasion the various flexures, courses, &c., of the currents of the Mississippi from the mouth of the Missouri downwards to Saint Louis. They are as numerous and multifarious as the materials of which the beds and banks of the river are composed, and the countless inequalities presented on the bottoms and sides of the channels through which the water of the river is conveyed.

Wherever and however these causes exist, the causes themselves as well as the results produced by them are liable to new changes and new modifications at every enlargement and at every diminution of the volume of water and velocity of currents flowing in their vicinity. But the anomalies attending these causes and their operations are so complicated and diversified that no data of a fixed and determinate character can be obtained in relation to them, and no deduction either satisfactory or conclusive can be drawn therefrom.

Accordingly a brief recital of facts and circumstances showing the condition of the river and of its channels, changes, &c., in the vicinity of Saint Louis, in so far as matters of this sort have come within my personal knowledge and observation, will embrace all the information I shall attempt to give in the sequel of this paper.

In my report to the Topographical Bureau, dated September 1, 1843, the following remarks in relation to the harbor of Saint Louis were introduced:

"The quantity of water that passes on this side of the river (the Illinois side) is thought to be very considerably larger, especially in a high stage, than that passing in the Missouri channel. Formerly the main body of the river in all stages passed between the island (Bloody Island) and the Missouri shore; the channel on this side being about a quarter of a mile wide, and twelve to twenty and in some instances thirty feet deep in the lowest stage of water. The extensive bar at the head of the island is annually spreading toward the Missouri shore, and at the distance of about a mile above the main landing of the city has already approached so near that the space occupied by the present channel on that side is quite narrow. I have been credibly informed that the depth of water in it during the very low stage that occurred in November last (1842) was scarcely sufficient for the passage of a boat drawing four feet."

The remarks contained in the foregoing extract were predicated on various details of information derived from examinations and inquiries made by me in 1841 and 1842.

In 1844 my attention was again directed to an examination of the state and condition of affairs relating to the improvement of the harbor.

The changes noticed in the extract above given continued still in progress, and threatened results highly injurious if not subversive to the existence of the harbor. The sand-bar at the head of Bloody Island was still increasing in magnitude by accumulations of sand, and spreading downward between the island and Saint Louis shore, and laterally across the head of the harbor. The channel between this bar and the Missouri shore, near the Upper Ferry Landing, was reduced in width to two or three hundred feet, and in depth to about four feet, while the Illinois channel had been greatly enlarged both in width and depth. The quantity of the water and the speed of the currents flowing through the harbor were greatly reduced, while those through the Illinois channel were proportionately increased. Deposits of sand, &c., began to accumulate in the harbor, and to encroach injuriously upon the channel along the City Landing, while the augmented volume that flowed with accelerated speed through the Illinois channel contributed not only to the enlargement of this channel but to the removal of the main body and bed of the river farther and farther from the Saint Louis shore, by deep and broad encroachments made at every freshet upon the Illinois shore. About the close of this year (1844) it is believed that at least three-fifths of the entire volume of the Mississippi flowed through the Illinois channel, leaving probably less than two-fifths of the same to pass through the Saint Louis Harbor.

The state of things contemplated in the preceding paragraph continued to prevail and even to grow more alarming till the year 1845, in the course of which the influences affecting the currents of the river, and the circumstances of the case generally, seem to have undergone a material change for the better. The formation of a sand-bar stretching across the head of the Illinois channel, and serving to diminish the flow of water on the Illinois side, began to be apparent, while the width, depth, and water flow in the Saint Louis channel began to increase in a corresponding degree. These reversions continued to operate and produce results more and more apparent and favorable during that year.

In the course of the following year these amendatory changes had been carried on to such an extent that nearly or quite one-half of the entire low-water volume flowed through the Saint Louis channel and harbor.*

In the latter part of 1846, I was again requested to visit Saint Louis, for the purpose of examining the harbor and reporting a method of improvement that might be carried into effect simultaneously with the works then in progress, at the expense of the city corporation, and under the direction of its authorities; my report of that year contains the following remarks:*

* * * * *

From the foregoing extract it is manifest beyond all question that the amendments in the condition and prospects of the harbor had actually taken place and were in progress in 1846. Moreover, from my recent examinations it is quite as certain that these amendments are still in progress in a manner highly favorable to the improvement of the harbor on a scale commensurate with the exigencies of the growing commerce of Saint Louis.

Whether the works undertaken and prosecuted with a view to the improvement of the harbor have contributed to bring about the beneficial results above considered, or whether these results have been produced mainly by natural causes operating in a manner to change and modify the currents of the river, are questions that I am not fully prepared to answer; but that the works are of a character to give stability and permanency to the ameliorations that have already taken place in the harbor, and even to render the improvements more extensive and complete in all respects, there can be no reasonable doubt.

Without attempting any further discussion in relation to the changes that have taken place and are still progressing in the bed, channels, &c., of the river, or of the origin, progress, and efficiency of the works intended for the improvement of the harbor in former times, I now proceed to consider the nature and extent of the works heretofore done at the expense of the United States and of those commenced and partially completed by the authority and at the expense of the corporation of Saint Louis.

My recent examinations were made in presence of his honor the mayor of Saint Louis, and H. Kayser, esq., city engineer. To these gentlemen I am indebted mainly for the various items of information I have to submit in this paper, in so far as relates to the works that have been undertaken and put in progress for the improvement of the harbor and for other purposes, which are as follows.

The works done by the United States for the improvement of the harbor, in addition to the numerous examinations and surveys made on the same account, are as follows:

First. A dike or submarine wall of stones or brush, parallel to the Saint Louis shore, and extending downward from the lower end of Bloody Island about 2,800 feet. Of this work the lower portion, embracing an extent of about 750 feet, still remains; the residue, embracing a sort of pier-head, at the upper end of the original dike, has been

* The remarks, omitted here, appear in Appendix K of this report.

undermined and demolished, or scattered and sunk in the sandy bed of the river. The portion remaining now serves as a protection wall or wing to the westerly extremity of a stone causeway already commenced and now in progress by the city authorities, for the double purpose of damming up the Illinois channel and of forming a roadway connecting the island with the Illinois shore at Illinoistown. This work will be more particularly noticed hereafter.

Second. A dike of stone and brush, commencing at a point on the westerly shore of Kerr's Island, about a quarter of a mile above its lower extremity, and extending downward towards the head of Bloody Island, in nearly a straight direction, the whole distance being 9,600 feet. The upper portion of this dike, from its head at Kerr's Island to a point about 1,700 feet below, was commenced and partially constructed under the direction of Colonel Lee, at the expense of the United States. The materials of which this part of the work was constructed remain at the bottom of the river on the line of the dike, scattered and embedded in the sand.

I would here remark that of the various works proposed or recommended for the improvement of the Saint Louis Harbor, I have always regarded this dike, or a similar dike parallel to it, as represented by the dotted line on the sketch, as the most useful and important, and that my opinion of its utility and efficiency in effecting this object and in imparting stability and permanency to the improvement remains unchanged. I deem this work so essential to the attainment of the ends just mentioned, viz, the stability and permanency of the harbor improvements, that I unhesitatingly advise that the unexpended balance still remaining and applicable to this branch of the public service be forthwith applied to the construction, in whole or in part, of this dike, especially of that portion of it extending upward from the head of Bloody Island, about 3,600 feet, to a point hereafter to be designated.

The works treated of in the foregoing articles are said to comprise all that has been done by the United States for the improvement of the harbor, surveys, &c., excepted.

The works done and still in progress by the corporation of Saint Louis for the improvement of the harbor embrace the following detailed parts and appendages.

Third. A prolongation of the dike last mentioned, from the lower end of the stone-work mentioned in the preceding article, in a downward direction toward the head of Bloody Island, and through a distance of about 2,400 feet; this portion of the dike was composed of trees, brush, &c., weighed down with stone. No traces of this work are now to be seen, the whole of it having been either swept away by the river currents or embedded in sand at the bottom of the river.

Fourth. A causeway and dam about 1,900 feet long, reaching from the lower end of Bloody Island across the Illinois channel, abutting at the westerly extremity on the upper end of the United States dike, mentioned in article first, and at its easterly extremity on the Illinois shore.

This work, at and near its termini, has already been reared to a level with the surfaces of the Illinois bottom and of the island, or within about one foot of the proposed road-grade, which is about 7 feet below surface water of the memorable flood of 1844. The intermediate portions of the work are less advanced, having been raised somewhat more than a foot above extreme low water for a considerable distance midway of the channel, and gradually rising thence to the elevation already attained at its extremities. The structure thus far is composed of rude quarry stones, varying in size from one-eighth of a cubic foot to one and a half cubic feet, and deposited in riprap order along the line of the causeway. It has for its westerly termination a sort of pier-head at right angles, or nearly so, to the remaining portion of Lee's dike at the foot of the island, protruding from the present head of this dike some three or four hundred feet towards the Saint Louis shore, and is to be supplied with a paved ramp or escarpment adapted to the passage of carriages, &c., reciprocally between the ferry-boat and the roadway. From the junction of these two works the causeway pursues a direction inclining upward through a distance of about one hundred yards; then deflects considerably to the right and pursues a straight course, inclining a little against the current to its terminus on the Illinois shore.

Fifth. A series of jetties or transverse dikes on the westerly margin of Bloody Island, projecting 100 to 300 feet from the island shore in directions nearly parallel and inclining a little upward against the current of the river. Of these jetties there are ten in number, arranged along the side of the island at various distances asunder, from its lower extremity to a point about a quarter of a mile below the head of the island.

In connection with each of these jetties, both above and below in its immediate vicinity, were originally two ramps or escarpments paved with stone, extending upward and downward 150 to 300 feet along the island shore.

The jetties still remain nearly entire and in the positions originally occupied by them, but the escarpments, from the surface of the island downward 8 or 10 feet, have been demolished by high-water currents, leaving their lower portions embedded in the sand at the bottom of the river.

The series of jetties above considered is proposed to be extended by adding another traverse dike at or near the head of the island. The length of this dike will probably

be about 200 yards, and its position such that it may serve as a protecting wall, at right angles with and at the lower extremity of the dike mentioned in article second, as originally projected.

These jetties, &c., are undoubtedly objectionable by reason of their tendency to prevent the enlargement of the channel between the island and the Saint Louis shore, a result likely hereafter to be desirable, as will be shown in the sequel.

Sixth. Two traverse dikes or stone jetties protruding from the Illinois shore in parallel directions, slightly inclined upward against the current, as before mentioned.

The lowermost of these dikes is situated at Brooklyn Landing, and extends from the shore about 2,000 feet to the line of the dike mentioned in article second and in the preceding article. About 200 yards of this dike, extending from the shore entirely across the deepest part of the Illinois channel, is at this time nearly completed. The remaining part of this work has been commenced, about one-third of the stone required for its completion having been already deposited. The upper transverse dike is situated on the same side of the river, about midway between the dike last mentioned and the foot of Kerr's Island, and extends from the shore about 360 yards to the line of the dike previously referred to in article second, &c. About half of the work required for the construction of this dike is already done.

Both of these dikes are to extend a considerable distance beyond the line of the dike above referred to, in the form of pier-heads, which may hereafter serve as ferry landings.

A third traverse-dike at the foot of Kerr's Island nearly parallel to those already noticed in this article and extending from the mainland shore to the same line of dike, is also intended to be formed, but as yet nothing has been done toward its construction.

It should be observed that the various dikes and jetties (except the prolongation mentioned in article 3) that have been undertaken and are now in progress at the expense of the city are all to be constructed of quarry stone of the character and dimensions stated in article 4; also that these several works are to be reared to an elevation nearly uniform, and about seven feet below the summit of the great freshet of 1844.

In addition to the works specified in the foregoing articles, measures have already been taken at the expense of the city for straightening the upper city landing from a point opposite to the head of Bloody Island upward toward a point of woodland called Sawyer's Point. Measures have also been taken for straightening and enlarging the city landing, from the head of the burnt district downward toward the United States arsenal. In furtherance of these measures large deposits of earth are now being made at both localities with the view of forming broad escarpments paved with stone, by means of which the area of the city landings may be enlarged to any extent that the commercial business of the city may require.

On the completion of the several dikes and jetties above considered, it is obviously manifest that the entire volume of the river, from the lowest stage to the summit of ordinary high freshets, embracing a range of about 27 feet, must pass between Bloody Island and the Missouri shore.

From the statement just advanced a question of no inconsiderable moment arises, viz, whether the Missouri channel, limited in the manner therein contemplated, will be sufficiently capacious for the conveyance of so large a volume of water without affecting the stability and permanency of the works?

A satisfactory and conclusive answer to this question involves a variety of considerations too complicated for our present use and purpose. A very few of those more immediately connected with the case and involving the most authentic data at my command are of the following import:

Assuming 34 feet as the range from extreme low water to the summit of the great flood of 1844, the highest freshet of the Mississippi of which we have any positive knowledge, which is probably very near the true maximum range at Saint Louis, and deducting therefrom 7 feet, which is the elevation of that flood above the tops of the dikes, jetties, &c., when completed, we shall have 27 feet as the range of freshets from extreme low water to the greatest height of surface water at and below which the entire volume of the river must flow through the Missouri channel when those works shall have been completed.

We shall again assume 1,400 feet as the width of the Missouri channel at the narrowest place between the Saint Louis shore and Bloody Island, and 24 feet as the average low-water depth of the same, both of which are very near the truth. We will also assume 2,000 feet as the width of the river at its narrowest pass, about two miles above Saint Louis, and 17 feet as its average low-water depth at this pass, both of which in like manner are approximately true.

Again, let us suppose that the width of the channel in both places respectively will remain constant and invariable, whatever may be the depth of the water passing through either of them, although we know that the width will increase more at the point last mentioned (two miles above Saint Louis) at every succeeding rise of the river than at the point near Saint Louis previously mentioned.

Let us moreover assume 2 feet above extreme low water, as the ordinary low-water level, and we shall have for the range above that level to a stage at which the river is on a level with the summits of the dikes, when completed, thus giving 25 feet as the extent of the range. In addition to the data exhibited as above, we shall also assume that the speed of the low-water current at the narrow pass above Saint Louis is 3 miles per hour, and that this speed will be accelerated at that pass half a mile per hour for every rise of 5 feet above that stage.

The foregoing rates and assumptions are believed to be very nearly correct, in no case exceeding the bounds of truth, and will be employed as elements for the computation of a series of tabular results, likely to be obtained during the progress and on the completion of the works herein considered.

Table of currents, &c., for different stages of water in the harbor of Saint Louis.

Stages from lowest to summits of dikes.	Sectional areas of the narrowest channel.		Corresponding velocities of the channel currents.	
	Above Saint Louis.	At Saint Louis.	Assumed velocity above Saint Louis.	Computed velocity at Saint Louis.
<i>Feet.</i>	<i>Square feet.</i>	<i>Square feet.</i>	<i>Miles per hour.</i>	<i>Miles per hour.</i>
Lowest Stage	30,000	30,800	2.75	2.673
2.....	34,000	33,600	3.00	3.034
7.....	44,000	40,600	3.50	3.793
12.....	54,000	47,600	4.00	4.537
17.....	64,000	54,600	4.50	5.274
22.....	74,000	61,600	5.00	6.006
27.....	84,000	68,600	5.50	6.734

Agreeably to the foregoing table it appears that the speed of the current through the narrowest part of the harbor, when the surface of the river is on a level with the contemplated summits of the works, will be at least $6\frac{1}{2}$ miles per hour. In view of such results, apprehensions may fairly be entertained that the velocity and power of the current will be likely not only to impair the commodiousness of the harbor, but to endanger the stability of the works.

I would accordingly advise that the condition of the harbor and the influences of the currents on the bottom and sides of the channels at and near the harbor, and the various works designed for its improvement, be carefully observed while the works are in progress, in order that their elevation may be limited to such a height as will be likely to obviate and prevent any disastrous consequences of the character above mentioned.

I would also recommend, as before intimated, that the unexpended balance of the appropriations for the improvement of the harbor of Saint Louis be applied, with similar precautions, to the construction of the dike originally projected by Colonel Lee, commencing at the head of Bloody Island and extending upward till it intersects the line of the dike at Brooklyn mentioned in the third article of this paper, and that this work be done under the direction of the topographical bureau.

I have the honor to be, sir, very respectfully, your obedient servant,

S. H. LONG,
*Lieutenant-Colonel Topographical Engineers
and Superintendent Western River Improvements.*

Col. J. J. ABERT,
Chief Topographical Engineer.

P. S.—The accompanying sketch will show the position of the several works, &c., treated of in this report.

S. H. L.

N.

REPORT OF MR. HENRY KAYSER, CITY ENGINEER, TO THE BOARD OF ALDERMEN OF THE CITY OF SAINT LOUIS, MISSOURI.

CITY ENGINEER'S OFFICE,
Saint Louis, December 11, 1849.

GENTLEMEN: Some weeks ago the petition of the Madison County Ferry Company, setting forth that by the harbor-marks above the head of Bloody Island their ferry landing on the Illinois shore was destroyed, and praying that a landing may be made

for them by the city, together with the report of the committee on harbor upon said petition, were referred to the city engineer, with instructions contained in said report, to state to the board "whether the facts of injuries set forth in said petition are caused by works now going on for the improvement of harbor, &c., at the head of Bloody Island by contract and compact entered into by the city with the State of Illinois, and, if so, whether the work can be changed so that the landing named in the petition be not injured, without violating the compact entered into by the city with the State of Illinois, and also what it will cost to repair said ferry landing to make it safe and the works go on."

Under these instructions I have the honor, first, to state the following :

The landing at the Illinois side of the Madison Ferry Company formerly and until about the year 1840 was at Brooklyn, a little town on the Illinois shore, about midway between the foot of Kerr's and the head of Bloody Island. In consequence of large bars lying opposite to Brooklyn, in the middle of the river (the creation of which was caused by the great width of its bed at that place), the crossing to this landing during low stages of the river was often attended with difficulties. The said bars were still enlarged, and the difficulties of crossing increased by the effects of the longitudinal dike running from the western shore of Kerr's Island toward the head of Bloody Island, projected and commenced by the United States in 1838, and afterward continued by the city of Saint Louis, and a new landing place was selected about the year 1840 at the principal street of Venice, a town laid out on said Kerr's Island at or near the junction of said dike with the western shore of the island, where, on account of the narrowness of the bed of the river, at all times a good channel of the river exists.

From ordinance No. 805, passed in August 23, 1841, it appears that the city of Saint Louis paid to the Madison Ferry Company the sum of \$3,000 in full for all damages done them by the United States or the city of Saint Louis, or that might thereafter be done them by the authorities aforesaid, in the prosecution of the works designed to improve the harbor of Saint Louis; the said ferry company entering into obligation to expend said money in improving their ferry landing. Whether or how said money was expended, I am not able to say. In order to pass the slough separating said Kerr's Island from the Illinois main shore at all stages of the river, a wooden bridge was built over the same. This bridge was carried off by the high water in 1844. Since that time, during the high stages of the river, when the same fills the slough, the ferry is compelled to make its landing immediately below the mouth of the slough and the foot of Kerr's Island, on the main shore, and, during low stages of the river, when there is not sufficient water over the said longitudinal dike and the bar created by the same, and the cross-dikes building from the main shore to the longitudinal dike, and when the said slough is dry and passable, the ferry makes her landing at the aforesaid landing-place at Venice. The connection of said longitudinal dike with the shore on Kerr's Island is intended to be made by cross-dams intersecting the said longitudinal dike right angular and rising gradually up to the top of the shore. Only the foundation of these cross-dams has yet been laid; one right at the above-mentioned landing at Venice, another one little further down, and a third one at the foot of said Kerr's Island, above the mouth of the slough. The continuous high-water of the past season has washed a part of the shore bank at the most upper one of these cross-dams off and disconnected the same from the shore; consequently, the distance between the shore and the longitudinal dike being increased, the latter at low stages of the river, when the ferry has to make its landing there, becomes an impediment to the approach of the boat to the shore.

The works now going or contemplated to be carried on above the head of Bloody Island, under the compact with the State of Illinois, are two cross-dikes and the continuation of the said longitudinal dikes towards the head of Bloody Island. Both said cross-dikes are running from the main Illinois shore across the bed of the river and intersecting the line of the aforesaid longitudinal dike, one about midway between the Venice and old Brooklyn landing, and the other at said Brooklyn landing.

Having given the above information, which is necessary for a correct understanding of the subject, I now pass over to the points I am instructed to report upon.

First. Whether the facts of injuries set forth in said petition are caused by work now going on for the improvement of the harbor at the head of Bloody Island by contract and compact entered into by the city with the State of Illinois?

From what has been said above, it will be recollected that the obstructions to the first landing-place at Brooklyn were increased and extended by the longitudinal dike, and there is no doubt that the continuation of said dike and the building of the two cross-dikes make also the landing-place below the slough and foot of Kerr's Island unavailable during the lower stages of the river. It also has been stated already that since the upper end of the longitudinal dike has been separated from the shore opposite Venice, by its being washed off, the landing-place there is made inaccessible during low-water.

2d. Whether said works at the head of Bloody Island can be changed so that the

landing be not injured without violating the before-mentioned contract with the State of Illinois, and what it will cost to make the landing safe?

There is no change required for that purpose. It is only necessary to raise one of the above-mentioned cross-dams from the elevation of the longitudinal dike gradually up to the elevation of the shore-bank, which, as before said, lies within the plan of the works. This can be done as soon as the weather will allow it. Such cross-dam will, of course, not have width enough to serve as a landing-place, but, under its protection, an embankment of earth and brush can be made wide enough for a road (say 60 feet), which will serve as a safe and commodious landing during all stages of the river, and give additional strength to the head of the works for the improvement of the harbor.

The said embankment (not including the stone work, which as before said constitutes a part of the work contemplated), if made at the point where the ferry usually landed, to wit, in front of the principal street of Venice, will cost about \$150, and if made somewhat further down, where the present owners of the ferry, as I am informed, desire it, will cost about \$500.

I have the honor to be, very respectfully, your obedient servant,

HENRY KAYSER,

City Engineer.

To the honorable Board of Aldermen of the City Council of Saint Louis.

O.

EXTRACT FROM REPORT OF MR. SAMUEL R. CURTIS, CITY ENGINEER, TO THE CITY COUNCIL OF SAINT LOUIS, MO.

CITY ENGINEER'S OFFICE,

Saint Louis, October 10, 1850.

* * * * *

HARBOR OF SAINT LOUIS.

The plan originally suggested by Lieutenant (now Major) Lee, of the United States Corps of Engineers, to improve the harbor of this city, in 1837, suggested the construction of works on the Illinois side, which were to check the wash and reflect the current on to the shore which forms the levee in front of the city of Saint Louis. The works have progressed with various modifications of the plan until an agreement was entered into between the city of Saint Louis and the State of Illinois, which prescribes and restricts the city to a certain plan designed and calculated to carry out the same results originally contemplated by Major Lee. A strict adherence to the plan thus prescribed requires the city of Saint Louis to erect, 1st, a road, "C N," from the lower end of Bloody Island to the Illinois shore; 2d, a dike, "W," above the head of the island, running out from the Illinois shore about 2,000 feet perpendicular to the river; 3d, a dike, "V," above this and opposite Venice, which is to extend out about 1,000 feet; 4th, a "longitudinal" dike from Venice, down to the head of Bloody Island, a distance of about 9,600 feet. A large amount of work has been done on all these dikes, but a larger amount is still required to carry out the plan prescribed by the contract with the State of Illinois. The lower dike, which is to be made into "a road," is about 10 feet above the river, entirely across the channel east of the island, and so far finished as to prove the success of the cross-dikes. The contractor, Mr. Schreiber, has met with those slips and other casualties which river work is often liable to, but the work is rapidly progressing, at a considerable loss to this contractor. To complete this dike into "a road" it may be widened with earth, and the stone delivered may be distributed so as to protect the remainder of the work. To make it more safe the road-way should be carried, say, 3 feet higher than the level of the "American Bottom," so that this dike will not be overflowed until the river has attained its greatest rise and general inclination, and will spread over a large surface; the current will be greatest in the river channel, and on the extended plane where the effect will escape the roadway, which otherwise would be liable to a fall over it which will react below and destroy it. This dike or "roadway" should be regarded as the base which is to protect all the other works, for it creates a pool above and an eddy below for miles along the adjacent shore of the Mississippi. It should, therefore, be fully completed and protected by every necessary auxiliary before another great rise in the Mississippi River.

The dikes "W" and "V" are advanced so that the stone may be seen during their entire lengths, generally above and near to the surface of water at its present low

stage. It is, therefore, the best time to progress with these dikes, which by the contract with Illinois should, if possible, be completed before the first of next February. All the cross-dikes which I have named co-operate and tend to narrow the river channel and reflect it against this shore, where it strikes the revetment which we are making on the levee or wharf in front of the city. They improve the harbor, and by being enlarged into roadways they will serve as convenient approaches to the city from the Illinois shore. Their completion will justify the end subserved, and the interest of both shores may be advanced by this reduction of the space between them. But the "longitudinal" dike proposed from the town of Venice to the head of Bloody Island is a very different affair. Besides its great length, near 10,000 feet, it is to run in from ten to forty feet in depth of water, where the foundation of the river is alluvial formation. Very little of the old work on this dike remains, and with some experience on the Muskingum, in Ohio, and the Des Moines, in Iowa, where similar constructions have been made under my supervision, I do not believe this longitudinal dike can be made substantial for less than \$300,000.

It would be attended with much delay in its progress or great waste of labor from the frequent and long-continued high stages of water. The other cross dikes will sufficiently narrow the channel and divert the current, so that this dike is of no use as a harbor improvement. It would act to a limited extent in strengthening the cross dikes, but this advantage would be insignificant, and could not apply until after the cross dikes must have other supports, if any are necessary. Would this expensive dike, which is unnecessary as a harbor improvement, be of advantage to the State or any portion of the people of Illinois? I have already noticed the length and deep water in which this dike is proposed, and I may add that in some places it is projected 2,000 feet from Illinois shore. It is not designed to raise it above ordinary freshets, so that at every rise the water is expected to run over it. As the river would be contracted, there would be a difference of level between the water outside and inside of this dike, and when the flood came it must fall over and excavate deep planes on the shore or east side of this dike. It would not, therefore, become a revetment for the line of the Illinois shore, as it would tend to prevent rather than promote the deposit near to the east side of it. I speak of this not from mere theory, but from observation on works precisely similar. The shore must take its shape between the cross dikes, and you may afterwards revet it; but such a longitudinal dike as the plan and contract prescribe would be a barrier that would shut out all boats from the interior shore and require the construction of long, expensive dikes, to admit of a direct connection between the shore and river. Since, therefore, this dike would be of little or no use to either side, and would cost at least \$300,000, an effort should be made to procure a release from this needless expenditure. A fair presentation of this matter to the authorities of Illinois could not, as I think, fail to convince them of the propriety of dispensing with this item, which by the contract the city is bound to construct, and without a release from the contract damages may be recovered from the city for not complying with this unnecessary and expensive provision.

Profiles exhibiting the condition of the cross dikes are herewith submitted.

All of which is respectfully submitted.

SAMUEL R. CURTIS,
City Engineer.

To the CITY COUNCIL
Of the City of Saint Louis.

P.

EXTRACT FROM REPORT OF COL. WILLIAM E. MERRILL, MAJOR OF ENGINEERS, UNITED STATES ARMY, ON THE HARBOR OF SAINT LOUIS, MADE MAY 1, 1869, TO HON. NATHAN COLE, MAYOR OF SAINT LOUIS, AND FRED. BISCHOFF, ESQ., CITY ENGINEER.

PROJECT PROPOSED.

The central harbor being in good condition during the lowest stages, it is manifest that if we can make the northern harbor like the central we may expect the same results in it. In other words, if we can canalize this portion of the river to a sufficiently small section, giving it revetted and permanent banks, we may confidently expect a sufficiency of water for the purposes of navigation during the lowest stages. Moreover, when once this work is properly performed, we need have no further apprehensions about the angle under which the river current enters the city limits. It will

be forced through so narrow a channel as to make the variations of the current a matter of indifference.

If we could succeed in getting the river to abandon the Sawyer Bend and to take the eastern channel by Cabaret Island, we would doubtless attain our object, and a shoal extending from Venice westward would ultimately narrow the waterway to the prescribed width. But having concluded that no reliance could be placed upon any means under our control for effecting this change, it only remains to see if we cannot accomplish the same thing in a different manner. Our object will be to so contract the waterway in the northern harbor as to *force* the river to run in the channel which we wish, notwithstanding that it comes to us from the Sawyer Bend.

There is a permanent low-water channel already established in the northern harbor, though it is not alongside the city wharf. Either the city must move to this channel or the channel must be made to come to the city. The former method would be the more natural, and in an engineering point of view it would be much preferable. Our studies have shown us that in its natural condition a river has no right lines passing directly from a curve bending one way into another bending in the opposite direction. If, then, the northern wharf line were moved out to the edge of the bar and made to conform to the curve of the channel, we would have a naturally-formed river from below the Grand Chain to the elevator, the first curve extending from near the Grand Chain to Bissell's Point, and the second from thence to the Saint Louis elevator, the apex of the first being one and a half miles above the new mouth of Gingrass Creek, and that of the second at the Venice landing, their convexities being turned in opposite directions. With shore lines thus established in accordance with natural laws, there would be no difficulty in making permanent shore revetments or in keeping the channel from changing. The great objection to the adoption of this plan is that much work has already been done on a different one, and large sums have been spent in establishing the present northern wharf line and landings. There would also be some difficulty in lengthening the established sewers, and it would take some time to raise the reclaimed sand-bar to a sufficient height for building purposes. Though the city would require all the new-made land, being the riparian owner, the owners of the property originally condemned for wharf purposes would have a claim for indemnity for the change of plan, and there would probably be numerous legal complications. The front dike already built and the North Market street landing would have to be abandoned, and the cross dikes would require extension to the new wharf-line. Under these circumstances, the only course that seems left is to force the river to come to the wharf which the city has established. That this can be done, I have no doubt, though the channel so formed will be an unnatural and therefore an expensive one, and the deflecting works will require frequent repair; still, as there seems to be but three ways of attaining our object, and as we have decided the first to be impracticable and the second to be open to very serious objections, the last seems to be the only one that can be taken. To force the low-water channel over to the city wharf, we must drive it from the Illinois shore by a series of dikes. The dike already constructed by City Engineer Bischoff will be the first of the system, the long dike extended will be the third, an intermediate dike at or near the Venice landing will be the second, and the fourth dike may be needed at the head of Bloody Island. These will be the main dikes, and the higher they are constructed the better. I would recommend that at all events they be raised to the height of 14 feet above low water; that being about the relative height of the most effective dikes on the Garonne.

On the map constructed by Mr. Rapp there are two lines drawn parallel to the wharf line, one distant 1,560 feet and the other 1,500 feet. The first line was placed at the distance indicated because this width at Pine street had been successful in keeping up a navigable channel in low water during eighteen years (dating from the closing of the passage east of Bloody Island). Were the circumstances at the two places exactly similar, I would think this the best width for the northern harbor, as the necessity of providing for floods compels us to adopt the maximum allowable low-water width; but considering the very unfavorable angle under which the river crosses the city boundary and the fact that the deepest water will in all cases be along the eastern shore and close to the ends of the dikes, I have thought it safest for the new waterway to reduce this width to 1,500 feet.

It is fortunate that we have not to deal with a river concerning whose action and necessities we are solely dependent upon theory and analogy. Works to improve the harbor have been carried on for thirty years, and, though but partial measures, they have been attended with a very fair amount of success. Undoubtedly the results accomplished could be secured now, if we had to begin again, with a less expenditure; but it is because we have obtained valuable experience from past essays and failures. Comparing the condition of the harbor of Saint Louis now with its condition in 1837, the city can certainly congratulate itself upon the measure of success which has attended its past expenditures.

The first three dikes of the system indicated should be constructed during the ensu-

ing season to a height of 8 feet above low water. The first is already built, the second is entirely unbuilt, and the third is partially built, requiring an extension of 900 feet. After they have stood one season's high water, they should then be raised to the height of at least 14 feet above low water.

The middle dike of the third will be 3,130 feet below the upper dike and 3,160 feet above the extension of the long dike, being nearly equidistant between the two, though nearer the upper, as it should be.

The complete reconstruction of the eastern shore would necessitate a longitudinal dike, connecting the extremities of the perpendicular ones; but experience with the old United States dike shows that without constant heavy expenditure such a dike cannot be kept up. The bottom of the Mississippi is so light and so readily washed out that such dikes are constantly being undermined throughout their entire length, and this action must continue until the stones forming the outer slope of the dike have slipped down so far that the foot of the slope is below possible scour and the bank on which it rests is thoroughly covered with stone. The discussions for the bridge over the river have brought out the fact that the deepest water known in the river at this place is 30 feet below low water, though it is believed that a depth of 40 feet may sometimes be found in exceptional places near obstructions, such as ends of dikes, &c.

Were this longitudinal dike constructed, it would be similar to the longitudinal portion of the Grand Chain dike, the average cost of which, allowing \$20,000 as the cost of the perpendicular part, was \$36 per running foot; and it is already in need of very expensive repairs. The cost of this dike, supposing it to extend only from Bischoff's to the Long dike, would therefore probably be \$226,440, too large a sum to be expended unless absolutely necessary.

A complete improvement would call for both kinds of dikes, but, as the formation of the new shore line is not necessary to our object, we may omit the longitudinal dike. The river will be forced over to the westward just as effectually by the perpendicular dikes alone, though not quite so smoothly. The ends of one of these dikes, and probably one or two hundred feet adjacent to the ends, will require occasional repairs for several years, until the lower layers have reached a point below possible scour; but the vast difference between protecting three isolated points and protecting a length of 6,290 feet can be seen at a glance. Moreover, the perpendicular dikes are necessary in any event, whether or not the longitudinal dike is used. Should it appear that the width assigned of 1,500 feet is too great to secure the required depth in the canalized river, it will be an easy matter to extend the three dikes to any desired proximity to the city wharf.

The length of the new dike at Venice, if constructed from the ferry landing, will be 1,070 feet, or 1,150 if constructed just above the landing. The increase in length to be given to the long dike is 900 feet, and its entire length should be raised at once to 8 feet above low-water.

It may be desirable during the progress of the construction of the new works to assist the river in removing the bar which now occupies the place where we expect to make the new channel. Any help of this kind will diminish the velocity and the scouring action of the current around the heads of the new dikes, and thus the amount of space to be filled with stone will be lessened, and the cost to the city will be less. A few days' or weeks' work by the United States dredgeboat after the dikes are begun would be of unquestionable benefit.

After the construction and settlement of these three main dikes it will be necessary, in order to secure a regular channel, to build smaller intermediate dikes from the new shore to the established eastern line. These, however, should not be commenced until the main dikes have operated sufficiently long to raise the bars between them above low-water, so that the shore connections of the small dikes may be cheaply constructed out of the sand of the bar protected by riprap. Only the outer portion will have to be built of stone, but the exact required length cannot be predicted.

Bischoff's dike is the keystone of the system recommended, and it has to bear the brunt of the shock of the river, striking it at a very unfavorable angle from the Sawyer Bend. But the river current alone, even should it attack it under a still more unfavorable angle, is powerless to affect it except by undermining the western end. This must be expected and provided for by raising the dike as fast as it sinks, and in course of time the undermining must cease. Broken stone, such as is used in the dikes constructed in this vicinity, is the best possible material for the purpose. Any rigid structure becomes impaired and destroyed by undermining, but this material merely slips down and readjusts itself into a new arrangement every whit as good as that originally made. The engineer need not trouble himself about hidden defects near the bottom of the dike that may destroy it, for none such can exist, and he has merely to throw stone on top as the dike sinks. On the Garonne the perpendicular dikes were generally constructed of piles, but our experience with the United States dikes shows that such structures will not answer for this locality. Broken stone alone will

do, and fortunately the numerous quarries in the vicinity will enable us to get it at a very reasonable rate.

But the construction of these dikes will not alone give a satisfactory solution to the problem. The greater the westward elongation of the river in the Sawyer Bend the more unfavorable the angle under which the river enters the city limits and the greater the scour at the heads of the pushing dikes. Unless defensive measures are taken in the bend this angle will become more and more objectionable, and, besides, it is very important for the city that no injury accrue to the valuable property which it owns at Bissell's Point, where the new water-works are being constructed. In 1843 there was a margin of 650' between Gingrass Creek and the river near the apex of the Sawyer Bend. In January, 1868, the survey then made showed that the creek had been reached and cut off from its former outlet. It is essential that the abrasion from Bissell's Point to the new mouth of Gingrass Creek be stopped at once. If this can be done and the river prevented from cutting in any farther to the west, the harbor interests will be protected as well as the water-works interest. The commissioners for the new water-works are content, as I understand it, with the river as it is, but are in dread of possible future results from its abrading influence in the bend above them. The low-service engine, inlet-pipe, and settling-reservoirs are well adapted to the present condition of affairs, and will perfectly fulfill their objects if this condition be not changed. We are, therefore, doubly impelled to stop the wash in the lower portion of the Sawyer Bend. I do not think that there is any necessity of extending the protection above the new mouth of Gingrass, though as the wash above continues a slight extension of the protection may from time be necessary.

There are two ways of protecting this shore—by a series of dikes or by revetment. We may build a few long dikes or many short ones, but in either case the expense would differ but little from that for a revetment and the result would not be so satisfactory. Hagen says on this subject: "As a general principle, jetties are not considered advantageous to a shore if the preservation of the latter is desired. If the shore be covered by revetment or by planting willows, and be properly sloped, the desired end is more easily accomplished. Jetties, first of all, decrease the action of the current on the shore but little, and at their heads great depth is produced, which is disadvantageous to navigation. In high water, when the jetties are overflowed, the action on the shore is very great, much more so than if the shore lines were unobstructed."

The trouble with jetties or perpendicular dikes seems to come almost entirely from the injurious action of the eddies. To keep the eddies off from the shore there must be a series of dikes so near to each other that each may intersect the normal path of the eddy from the one above, forcing it to form a smaller ellipse, whose conjugate axis will be too small to permit it to touch the shore. This must hold for all stages of water, and, therefore, in order that the dike may be an effectual protection it should be as high as the bank to which it is attached, and should keep this level far enough out to prevent the eddy, even when the river is bark-full, from touching the shore. Such dikes would probably be more expensive than a revetment. Moreover, the time is not far distant when this part of the river bank will be included in the city limits. The city will then be the gainer by having a wharf all finished except the reduction of the slopes. It is merely doing now what will have to be done before many years; while, if we use dikes, we have the entire wharf to build, the effect of the dikes being only to make it extend a little farther east. The natural bank should be sloped at an angle of 45° to the water's edge; the surface should be protected by riprapp and the bottom by a low longitudinal dike. The cost of this protection I have estimated very carefully from the records of similar expenditures in the past as recorded in the city engineer's office. The distance to be revetted is 10,000', and the height of the bank is taken at 25':

115,926 cubic yards excavation and grading, at 35 cents per yard	\$40,574 10
3,536 squares riprapping, at \$4.75	16,796 00
10,000' longitudinal dike, at \$7.73	77,300 00
Cost of protecting, 10,000' of river bank	134,670 10

The cost of excavation and grading supposes that some of the earth removed is put into a high-water levee, and the price is the same that is now being paid for similar city work. The price of riprapping was similarly determined, the allowance made for the stone being \$1.41 per perch, which is the price of the last contract. The cost of the front dike of the wharf, northern, from Montgomery to Florida street, a distance of 5,000 feet, averaged \$10.98 per linear foot, with stone at \$2 per perch; with stone at \$1.41 per perch, this becomes \$7.73, the price given above. It is claimed that in selecting the new site for the water-works the city saved \$4,000,000. As the new site required protection, the water-works commissioners might well afford to contribute to that object; and it also seems but reasonable to look for some assistance from the land-owners, whose property will be so largely increased in value by the works recom-

mended. Many industrial establishments would gladly remove to a place where they can have a free wharf, with ample depth of water during all stages of the river.

In estimating the cost of the new dike at the Venice landing, and of the extension of the long dike, both raised to the height of 8 feet above low-water, I have taken the actual cost of Bischoff's dike, and have assumed that the cost of the new works will be proportioned to their respective lengths. This is a much more reliable method than any that is based upon the assumed amount of stone that will be required, as it is simply impossible to determine this, everything depending upon the effect of the current on the dike, and on the bottom while the dike is being constructed. This method of calculation, making allowance for the reduction in the price of stone from \$1.70 per perch to \$1.41, the price at which the contract for the new dike was awarded, would give—

For the new dike at Venice.....	\$53, 835
Extension of the Long dike.....	45, 424
	<hr/> 99, 259
Add estimated cost of revetment above water-works.....	134, 670
	<hr/> 233, 929

In the future we shall probably require some short intermediate dikes, and probably a main dike at Bloody Island, but it is barely possible that some or all of these may be found unnecessary. At all events they need not be estimated for now. The work recommended, however, will evidently need repairs for several years, until the new regimen of the river is settled. Estimating the cost of this at 10 per cent., we may safely call for an appropriation for harbor improvement of \$250,000. As the greater portion of the work recommended should be commenced this season, and it is of the greatest necessity that a fund should always be available for repairs immediately needed from time to time, I would respectfully recommend that measures be taken at once to secure this sum for the preservation and improvement of the harbor.

The central and southern harbors are in good condition, deep water being found along the city wharf to the southern limits. As the works I have recommended will necessarily modify the regimen of the river above, no harbor work should be attempted below the middle of the city until these works have developed their full effect. The lower harbor, however, should be watched, and any tendency of the river to return to its former bed in Cahokia Bend should be checked at once.

The new dykes should be constructed *in horizontal layers of the full length of the dyke*, the lowest layer being made as nearly as possible as wide as the base of the finished dyke and about three feet thick. It is very difficult to accomplish this in a rapid current; but it should be attempted, as it will prevent the river from cutting out the bottom as the dyke is being built, thereby increasing its cost. It being very difficult to place small stones in a rapid current, it will be best to have the minimum size fixed at 250 cubic inches; but no stones too large to be lifted readily by one man should be permitted, as they leave very large interstices for the passage of the water, thereby diminishing the deflecting action of the dyke, and hindering the formation of shoals above and below. After the dyke has been built, small stones should be thrown along the upper side to make it tight. As the ends will be liable to injury from floating ice, the outer 200' should be protected by a facing of heavy stones, roughly laid to a height above the ice-level. The more sloping the ends of the dyke are made, as also the sides of the longitudinal dykes, the less the danger of undermining. If the ends are vertical, the little whirlpools that they form in the different strata of the water have their axis above each other, and their combined forces operate on the bottom. On inclined ends the most powerful whirls, those of the upper strata, are vertically over the revetted slopes, and act upon a protected surface, where their effect is neutralized.

The other details of construction are fully set forth in the contract drawn up for the new dike. The riprap of the shore above the water-works should be of four-inch stone set on edge, the front dike being made like the perpendicular one just described.

If the Madison County Ferry Company will co-operate with the city in building the Venice dike, and will raise it above high water, making a permanent roadway, with a new landing at the end, it will be a very great gain both to the city and to the company. If all the dikes could be raised to this height it would be very advantageous to the harbor, but the increase in cost is too great for the city alone to do it.

If at any time in the future the river should take the Cabaret Chute, the works recommended will be exactly what would be needed to secure the full benefits of the changed course.

The proper time for carrying on the harbor works recommended is during low water. Shore revetment is manifestly impossible during high water, and work on dikes is both more difficult and more expensive than when the velocity and scouring action of the current are less. The hydrograph of the river at this city, as compiled in the city

engineer's office since 1860, shows that the occasional great floods occur in June, but that for average years the highest water is about the middle of April, and that from the 1st of September to the 1st of March there is a continuous period of nearly uniform low water. I would not, therefore, recommend the commencement of any of the harbor improvements indicated in this report before the 1st of September, but unless the river should happen to be exceptionally high at that date, I think work ought to be begun then and pushed on vigorously, so as to be completed before the high water of next spring.

* * * * *

Q.

REPORT OF MR. M. LEWIS CLARK, CITY ENGINEER, TO THE BOARD OF DELEGATES OF
THE CITY OF SAINT LOUIS, MO.

OFFICE OF THE CITY ENGINEERS,
Saint Louis, March 15, 1841.

GENTLEMEN: Agreeable to instructions contained in a resolution passed by the board of delegates on the 27th January last referring to me the memorial of the citizens of the town of Brooklyn, in the State of Illinois, relative to a cross-dike or pier from the foot of Canal street, in that town, to intersect the prolongation of the upper or main pier, and to be constructed of good and substantial material 50 feet in width at the summit; and also directing me to examine the points designated, and, if in my opinion suitable, to survey the location and report to the board; and also agreeable to a resolution of the same date instructing me to ascertain whether the repairs of the upper pier might not be dispensed with in case the cross-pier should be erected, I have the honor to report that on the 1st day of February last I examined the points designated and made a survey of the location of the contemplated pier from Brooklyn, as also the main pier connecting Kerr's Island with the head of Bloody Island; but from the short time intervening between the completion of my surveys and the adjournment of the council on the evening of the same day, I could only make to your board a partial report, requesting further time for preparing a more full and detailed report and drawing of the work contemplated by the memorial, as well as the estimates therefor.

The location of the pier contemplated by the memorial I consider a good one, as doubtless was contemplated by its projectors, for the purposes of a street or roadway from Brooklyn to the Mississippi River; at the foot of which street or roadway it is desired by the citizens to establish this ferry landing. But, so far as I can ascertain, the owners of the ferry themselves do not desire this work to be done, or, at least, prefer the upper landing to that in front of Brooklyn; and, for the purpose of effecting a landing for their boats, desire a shorter pier from the Illinois shore and about an intermediate distance from between Brooklyn and the head of the main pier, which location I consider a good one, not only for the purpose of a road from there to the river, but also for the reason that it will be necessary, and I believe was contemplated by the United States authorities on adopting the plans for the work in the harbor, to connect the main pier between Kerr's and Bloody Island with the Illinois shore by cross-pieces or clamps at regular distances; the object of which is to break the current of the Mississippi in its passage over and around the main pier, as also to create such a check in its flow as will induce a deposition of sand and mud between them, thus to fill up the space behind the pier. Under this view I would recommend that the plan of these cross-piers should not be abandoned, but that they should be gradually erected and the main pier extended as originally contemplated, until it shall close in the whole space between Kerr's Island and Bloody Island. I am, however, of opinion that a strong pier thrown perpendicularly across the channel from the head of Bloody Island to the Illinois shore, as was originally contemplated by the United States engineer, would answer the purpose of throwing the water upon the Missouri side of Bloody Island, but would not effectually direct the course of the current as is desirable. This pier if established, as I presume it was, from what I have ascertained, became eventually one of the dams before spoken of, and as such be a part of the plan to be adopted. Under this view of the subject I think the work asked by the citizens of Brooklyn should be erected, being a part of the general plan so far as I can understand it in the absence of such correct information as should be in this office; but the dimensions stated in the memorial are not such as I can approve or recommend.

Fifty feet in width at the summit is wider than most of the streets of this city, and certainly the council cannot be expected by the memorialists to construct a street for the town of Brooklyn wider than they have adopted for the business streets of the

city. Twenty-five feet I should suppose would be sufficiently wide for the purpose, if piles were driven at regular distances for the purpose of protection, and left about 5 feet higher than the upper surface of the pier. The memorialists also desire the contemplated pier to be raised 8 feet higher than that to which it is contemplated to connect it. This height I must also disapprove as, expensive and useless, so far as any great advantage is to result from it even to the citizens themselves, for I am of the opinion that if the work be of such a height above the main pier as to allow a ferry-boat of ordinary draught, say 4 feet, to pass over the main piers before the streets should be inundated, it would be sufficient; the ferry-boat would then be enabled to pass on over the main pier to the present Illinois shore in front of the town of Brooklyn, and there land until the water should again fall below the surface of the street, and the extremity thereof would then become the landing. I can then only recommend the continuation of the Brooklyn pier or street, so as to form a surface of 25 feet, and which surface should be 4 feet only above the top of the main pier. I cannot conceive any immediate necessity for the erection of the Brooklyn pier or street contemplated so far as the harbor of this city is concerned; and should the council think proper to order the work to be done, it can only be for the accommodation of the citizens of Brooklyn, and by way of compromise with them for damages which they certainly have sustained in consequence of the prosecution of the works in the harbor above this city. In the event that the contemplated pier should be ordered, it would be necessary to prolong the present main pier until it intersects with it, and thence I would recommend its prolongation as soon as possible to the head of Bloody Island. The accompanying map of the upper harbor will explain to the board the locality of the several piers and dams I have spoken of, as also those projected. The distances, &c., are thereon laid down by actual measurement and such other data as I could ascertain from others, there being no map or other notes or information relative to the harbor in this office. In my former partial report on the subject of the repairs of the main dike I suggested the propriety of their being immediately repaired even should the cross-pier from Brooklyn be determined on, upon which report I was ordered to proceed therewith, which I have partly done, having repaired the most injurious breach; the remainder does not now require further repairs. It may be proper to state that I was directed by the acting mayor to suspend these repairs for reasons which I shall make the subject of another report. From the accompanying map it will be seen that the pier asked by the citizens of Illinois to connect the foot of Canal street with the prolongation of the main pier will be about 1,450 feet in length, being 8 feet higher than the pier now constructed, and 13 feet higher than low-water mark. The depth of water in which it is to be constructed will average 2 feet in low water, making the whole average height of the pier 15 feet, the summit being 50 feet in breadth, and the slopes 3 to 1 foot, adopted by the United States engineer for those now constructed, will give it a base of 140 feet. The pier thus constructed will contain 76,527 cubic yards of stone, which, at a cost of 25 cents per cubic yard, which I consider a low estimate, will give for the estimated cost of the pier \$65,000. If the pier should be reduced in width to 25 feet for the road, and in height to 4 feet above the top of the main pier, the cost may be estimated at \$29,000. In conjunction with this I give the cost and estimate for the extension of the present pier until it shall intersect the contemplated arc. This extension will be about 1,800 feet. The top, to correspond with that already erected, must be 10 feet broad and 7 feet average height. This extension will cost \$12,000, and if further extended, of the same dimensions, to the head of Bloody Island it will require the additional sum of about \$15,000. The pier desired by the ferry company, as I have above stated, and to be located as is represented on the map, would be 25 feet on the surface and 4 feet higher than the main pier, being about 900 feet in length, and may be estimated to cost \$18,000, but if the same height as the present main pier it will cost \$11,000.

Before closing this communication allow me respectfully to ask the attention of the board to my communication of February 1, 1841, wherein I reported that, agreeably to instructions, I had sold the piles belonging to the city. I have since deposited the proceeds of the sale—\$25—with the treasurer, and have his receipt for the amount.

I have the honor to be your obedient servant,

M. LEWIS CLARK,
City Engineer.

To the Hon. BOARD OF DELEGATES,
City of Saint Louis.

The first of these is the fact that the Government has not yet decided whether it will accept the offer of the United States to purchase the Hawaiian Islands. This is a matter of great importance, as the Hawaiian Islands are situated in the Pacific Ocean, and are of great strategic value. The second of these is the fact that the Government has not yet decided whether it will accept the offer of the United States to purchase the Hawaiian Islands. This is a matter of great importance, as the Hawaiian Islands are situated in the Pacific Ocean, and are of great strategic value. The third of these is the fact that the Government has not yet decided whether it will accept the offer of the United States to purchase the Hawaiian Islands. This is a matter of great importance, as the Hawaiian Islands are situated in the Pacific Ocean, and are of great strategic value.

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